# DOCUMENT RESUME

ED 024 236 EF 002 295

By-Larson, R. E.; Rust, L. W.
Maintenance of Mechanical Equipment in Minnesota Schools, 1968 Survey.
Minnesota State Dept. of Education, St. Paul.
Spons Agency-Louis W. and Maud Hill Family Foundation.
Pub Date Aug 68
Note-71p.
EDRS Price MF-$0.50 HC-$3.65
Descriptors-Bibliographies, *Custodian Training, Engineering Technicians, *Equipment Maintenance, Fuel Consumption, *Heating, Mechanical Skills, Repair, *School Buildings, *School Maintenance

Results of a one-year research program to study maintenance procedures for operating mechanical equipment were based on the determination of--(1) the present condition and level of performance of operating mechanical equipment, (2) the problems encountered by school administrators and custodial engineers pertaining to operating mechanical equipment. , and (3) the general level of competance exhibited by custodial engineers. The program consisted of a preliminary investigation followed by the establishment of an advisory committee, a questionnaire phase, and an on-site visit phase. The results indicate a high percentage of mechanical equipment in need of repair, poor heating practices in many buildings, water chemistry associated with boiler operation in need of attention, a lack of preventative maintenance programs and a need for additional maintenance training. Some of the recommendations of the study are--(1) the addition of an engineering staff to the school plant planning section of the Department of Education, (2) the establishment of training programs, and (3) the preparation of a maintenance procedure manual. A short bibliography is included. (NI)

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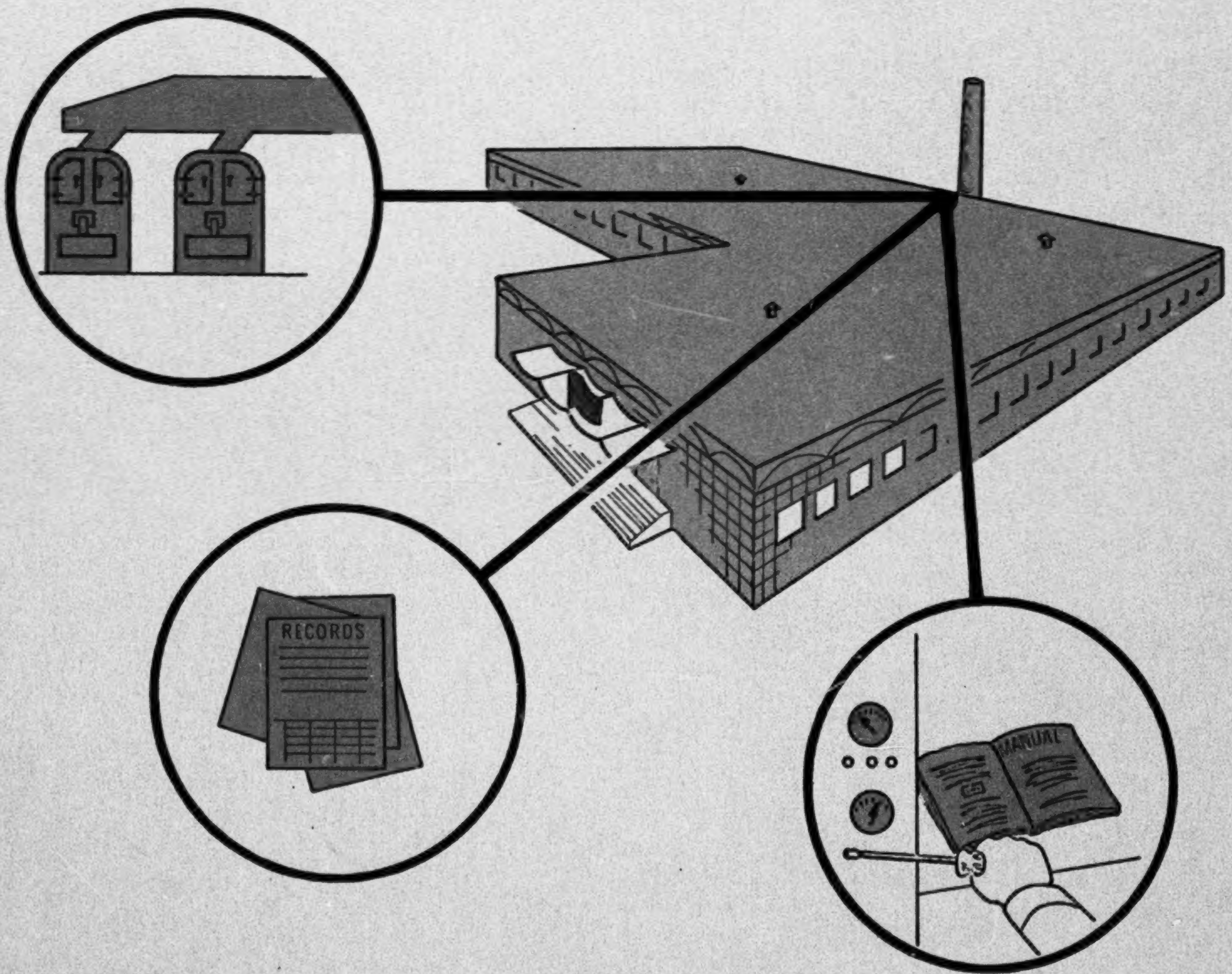
1968 SURVEY –

# MAINTENANCE OF MECHANICAL EQUIPMENT IN MINNESOTA SCHOOLS



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THIS STUDY WAS MADE POSSIBLE BY A GRANT FROM THE
LOUIS W. AND MAUD HILL FAMILY FOUNDATION
ON BEHALF OF THE
MINNESOTA STATE DEPARTMENT OF EDUCATION
AUGUST, 1968

EF002295

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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# 1968 Survey -

# MAINTENANCE OF MECHANICAL EQUIPMENT IN MINNESOTA SCHOOLS

by

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This study was made possible by a grant from the
LOUIS W. AND MAUD HILL FAMILY FOUNDATION
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August, 1968

# FOREWORD

To ensure that the transfer of knowledge between teacher and pupil takes place with the best possible efficiency, uninterrupted operation of the operating mechanical equipment in the school building is essential. Studies have shown that such factors as lighting, air quality, and background noise play a large part in influencing the performance of the teacher and the student's motivation to learn. The taxpayer makes his investment in the educational system in good faith, assuming that high-quality school buildings will be constructed, and the best available teachers will be hired. If the operating mechanical equipment in the school building is not functioning properly; the students and teachers are distracted or made uncomfortable, the taxpayer is not receiving a proper return on his investment. Further, improper maintenance procedures lead to early deterioration of the equipment, unexpected school closings, and increased operating expenses -- effects felt by the taxpayer in the form of higher taxes.

With these basic thoughts in mind, the study reported here was initiated to obtain information on this important aspect of the overall educational system -- maintenance of operating mechanical equipment in Minnesota school buildings.

The following article, reproduced from the May, 1967, edition of the Minnesota State Department of Education Report, informed school administrators of this study.

## MESSAGE FROM DUANE J. MATTHEIS, STATE COMMISSIONER OF EDUCATION TO STATE SCHOOL ADMINISTRATORS

### Hill Grant Made For Equipment Study

A grant to study the performance and maintenance of operating mechanical equipment in Minnesota Schools has been awarded the North Star Research and Development Institute. The $48,495 study will be financed by the Louis W. and Maud Hill Family Foundation.

The study will have two phases: questionnaires will be mailed to superintendents of all independent school districts in the state, and members of the North Star staff will visit a representative sampling of schools to evaluate conditions and maintenance procedures of operating mechanical equipment.

The State Department of Education endorses the study and encourages school officials to respond carefully to the questionnaires and assist Institute staff members who may visit their school.

"We expect the study to be quite helpful to board members and administrators," says Guy Tollerud, state director of school plant planning. "Specifically, in addition to improving management and efficiency of school operations while reducing cost, it will help in planning new schools."

The State Department is cooperating with the North Star Institute in the study, and will serve in an advisory capacity.

Education commissioner Duane J. Mattheis soon will announce a Department advisory committee to work with the Institute staff. The committee will include representatives from school administration, the school business officials, school board members, maintenance personnel, consulting engineers, and equipment manufacturers and suppliers.

Prompt replies to questionnaires are essential to the success of the project. Individual responses will be held in strict confidence by North Star, which will make public only the final results and conclusions of the study.

Questionnaires will be mailed about July 1. Some on-site visits will be made this summer when heating systems can be inspected carefully, but most will take place in the 1967-68 school year.

The North Star Research and Development Institute is a nonprofit, independent research organization which was established by the University of Minnesota and the business community of the Upper Midwest. It conducts scientific research in physical, biological, and social sciences and in engineering on a contract basis for industry, government, civic and educational groups, and foundations.

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# ACKNOWLEDGMENTS

It would have been impossible to carry out a program such as this, which involved every school district and public school in the state, without the cooperation and assistance provided by state officials, special consultants, school administrators, and school system employees. Their efforts are greatly appreciated.

The authors wish to express their special appreciation to Mr. Guy O. Tollerud of the Minnesota Department of Education for his guidance and advice during the entire program. Because of his activities as Director for School Plant Planning of the Minnesota Department of Education, Mr. Tollerud has long been aware of the importance of proper maintenance procedures for operating mechanical equipment in school buildings. He recognized the urgent need for a study to investigate the present status and level of performance of operating mechanical equipment in Minnesota school buildings, and was instrumental in initiating the research program that has now been carried out by North Star Research and Development Institute.

Financial support for the program was provided by the Louis W. and Maud Hill Family Foundation. The efforts of Mr. John D. Taylor, who monitored the study and provided valuable advice during the entire program, are very much appreciated.

Thanks are due to Mr. Leo A. Matthies, Consulting Engineer, who assisted in the planning of the program and carried out the on-site visits with tact and skill. Mr. Matthies' overall knowledge of the problem, gained during his many years of experience in the design of electro-mechanical installations for school buildings, proved invaluable as the program progressed.

The cooperation of the school district superintendents in distributing the questionnaires and seeing that they were returned to North Star is greatly appreciated. School principals, maintenance supervisors, and head custodians, who filled out the questionnaires and helped to coordinate the on-site visits, deserve commendation.

Finally, the authors wish to thank the members of the Advisory Committee that was formed by Education Commissioner Duane J. Mattheis to provide advice and guidance during the program. This committee includes representatives from school administration, school business officials, school board members, maintenance personnel, and consulting engineers. In particular, the efforts of Mr. Warren Soderberg and Mr. Darrell Westling demand special recognition. They provided valuable contributions during attendance at subcommittee meetings that were required to plan various phases of the study.

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## SUMMARY AND CONCLUSIONS

This report summarizes the results of a one-year research program carried out by North Star Research and Development Institute to study maintenance procedures for operating mechanical equipment (OME) in Minnesota public school buildings. Funding for this program was provided by the Louis W. and Maud Hill Family Foundation, and the program was guided by the Minnesota Department of Education.

The general objective of the program was to study and analyze the operation and maintenance procedures for operating mechanical equipment in Minnesota school buildings. It was decided that the basic objective could be best achieved by determining the following:

- The present condition and level of performance of operating mechanical equipment
- The problems encountered by school administrators and custodial engineers pertaining to operating mechanical equipment
- The general level of competence exhibited by custodial engineers

North Star's approach to the research program involved the following steps:

Step 1. Preliminary Investigation. Because of the complexity and importance of this problem, the effort during the initial part of the study was directed toward obtaining an overall appreciation of the basic problem and an insight into the related aspects of OME maintenance. No studies had been carried out that had the scope and content of the one being contemplated. However, a large amount of literature was available that pertained to some of the new maintenance procedures being carried out by various industrial organizations and private groups. The military has long been an exponent of preventive maintenance procedures, and it was known that some of their procedures are now being used by progressive maintenance personnel responsible for the care of operating mechanical equipment in industrial buildings. Conferences were held with educators, school planners, and builders to obtain their point of view and attitudes on maintenance and operation of OME.

Step 2. Establishment of Advisory Committee. A 17-member Advisory Committee was established to provide guidance and assistance in the planning and execution of the program. The Committee include representatives from school administration, school business officials, school board members, maintenance personnel, and consulting engineers. As evidenced by the list of members of this Advisory Committee presented at the beginning of this report, great success was realized in obtaining the cooperation of highly qualified people with the background necessary to assist North Star in this program.

Step 3. Questionnaire Phase. The study consisted of two separate data-gathering phases. In the questionnaire phase, groups of four questionnaires were sent to all independent districts operating graded elementary and secondary programs, and to area vocational-technical schools. The questionnaires consisted of both objective and subjective questions and were designed to provide facts rather than opinions whenever possible. Included in the group of questionnaires sent to each district was a local school district questionnaire to be completed at the district office, and other questionnaires pertaining to school building general information, personnel information, and school building maintenance, to be filled out at each school by appropriate school officials.

Step 4. On-Site Visit Phase. Visits and on-site observations were carried out at all levels of schools (elementary, junior-senior high school, junior high school, senior high school, and vocational) throughout the state. In total, 100 schools were visited, selected partly on a geographical basis and partly on a random basis. The major purpose of the on-site visits was to verify the responses to the questionnaires and, in addition, to gather information not readily obtainable by questionnaires.

The general condition of the equipment and maintenance procedures followed were observed, boiler water samples were taken, and analyses of the stack gas temperature and combustion products were performed.

All replies made in the questionnaires and information obtained during the visits have been kept in strictest confidence by North Star, and were not made available to any outside agency, group, or individual. Only the general results are included in this report, and no schools or individuals are identified by name.

The results of the study are summarized as follows:

1. The overall condition of OME is approximately 48 percent of the school districts rates between fair and poor. About 60 percent of the school buildings have some mechanical equipment that is out of repair and not functioning properly.

2. Considerable savings in fuel bills could result if proper heating practices were followed. Most of the schools are operating boilers with more excess air than necessary, and insufficient control is exercised in maintaining and monitoring the stack temperatures. As a conservative estimate, closer control of boiler operation could result in a 10-percent savings in fuel bills. It is estimated that the total annual fuel cost for all school buildings in the state is approximately 6.5 million dollars. Therefore, at least $650,000 could be saved each year. In some individual buildings having unusually bad conditions, savings of the fuel cost as great as 50 percent could be realized.

3. The water chemistry associated with boiler operation is in need of more attention. Premature failure of boiler components does result in many cases when this is not accomplished. In 44 percent of the schools visited, excessive iron was present in the boiler water, indicating corrosion. In 72 percent of the schools, excessive chloride was found in the boiler water, indicating an excessive amount of makeup water was being used. Such a condition arises from poor steam trap operation, piping system leaks, or other malfunctions. In 28 percent of the schools, too low a pH showed improper application of boiler compound. Finally, in 29 percent of the schools visited that had water softeners, the units (required for scale prevention) were not producing softened water.

4. The questionnaires and on-site visits indicate that the major problems encountered in OME maintenance can be related to the following:

- Poor design practices
- Improperly trained and inexperienced personnel
- Lack of proper scheduling and work records
- Absence of maintenance aids, such as equipment manuals, charts, and plans indicating equipment location, etc.
- Lack of funds and sufficient time allocation to perform proper maintenance
- Lack of adequate space
- Existence of much obsolete, neglected, and worn-out equipment

5. Of all items of OME in the school buildings, heating systems cause the most problems. In Question 34 in the School Building Maintenance Questionnaire, the maintenance supervisors were asked to indicate the type of equipment that gave the most problems. In their replies, eight of the first ten items pertain to the heating system (for example, unit ventilators, boilers, steam traps, boiler controls, and pneumatic controls).

6. Only 30-35 percent of the schools in Minnesota are following preventive maintenance programs for OME. The above figure can be substantiated by consideration of the following:

- Only 29 percent maintain a boiler log
- Only 30 percent keep a master maintenance schedule
- Only 38 percent have an equipment location chart
- Only 38 percent keep lists of equipment in the schools
- Only 55 percent keep files of maintenance instructions

The on-site visits showed that only 15 percent of the schools are keeping good maintenance records. In the School Building Maintenance Questionnaire, a group of mechanical equipment items were listed in Question 32. The respondent was to describe the type of maintenance performed -- preventive or breakdown. The majority indicated that preventive maintenance procedures were being performed on the items, despite the contrary conclusion drawn by the authors from answers to other questions. This indicates that many maintenance supervisors do not understand what a good preventive maintenance program is.

7. The majority of the maintenance supervisors and school officials believe that maintenance training programs are required. Approximately 82 percent of the maintenance supervisors believe that they need additional training. Of the maintenance supervisors who believed that additional training was required, 58 percent throught that the program should be carried out during the school year, and 35 percent, during summer vacation. There was little preference shown to whether the training should be offered during duty hours or during off-duty hours. The OME items for which the maintenance people thought advanced training was necessary were preponderantly related to the heating system, such as unit ventilators, boiler controls, boilers, steam traps, and pneumatic controls.

# RECOMMENDATIONS

It is difficult, in a survey of this type, to determine a precise percentage of school buildings in which the OME is poorly or inadequately maintained. However, the observations made during the on-site visits, combined with the results obtained with the four questionnaires, definitely indicate that no more than 30 to 35 percent (and probably less) of the school buildings are being operated under recognized preventive maintenance programs. This results in increased expenses to the school systems and can also affect the educational process. Annual repair, replacement, and maintenance savings in Minnesota school buildings could amount to 2 to 2.5 million dollars if proper maintenance programs were initiated throughout the state.

Several steps can be taken to improve the situation:

## 1. Strengthen the Capability of the School Plant Planning Section of the Minnesota Department of Education by the Addition of an Engineering Staff.

The results of this study indicate that a qualified engineering staff, at the state level, would be of invaluable assistance to local school districts in improving the design, construction, and maintenance of school buildings. The responsibilities of this section would include, but not be limited to, the following:

- Establish school building construction and engineering guidelines
- Review and approve plans for new buildings and additions
- Assist in the establishment of a maintenance program for all new buildings
- Assist in the establishment of maintenance programs for existing buildings
- Provide engineering services for solving design and maintenance problems in existing buildings
- Provide maintenance inspection services to local school districts

One of the major problems observed during the on-site visits can be attributed to poor building design and placement of equipment. In some cases, this is caused by the necessity of using an outdated or old building for more students than originally intended. In most cases, the so-called "poor design" is more probably a case of insufficient communication between the building engineers and architectural designers. Much of the observed design deficiency could be reduced by greater coordination of the efforts of people involved in the initial planning and designing of school buildings. These activities could best be coordinated through the School Plant Planning Section. A well-qualified staff of engineers could review proposed plans for new school buildings, as well as additions to existing school buildings. Such a review procedure would probably result in more useful and functional schools and, as a result, reduce the overall expenses of maintaining the school buildings. With an ongoing construction program of 80 million dollars per year, it is obvious that poor and uncoordinated planning would lead to wasteful expenditures that could amount to several million dollars per year.

The on-site visits of this study brought to light many conditions that should never have been allowed to occur, and probably would have been preventable with a properly designed maintenance program. Further, some potentially hazardous conditions were uncovered. It is recommended that a staff of two or three well-qualified maintenance men be established in the School Plant Planning Section, having the primary purpose of inspecting school buildings on a continuing basis. These men could offer advice and recommendations to the local school maintenance staffs, and point out existing problems along with possible solutions. To insure compliance, it is recommended that this office be provided with enforcement authority.

Based on the present study, it is estimated that a staff of three men could carry out a valuable and effective inspection program for the school buildings in the state at an annual cost of $75,000. Considering that the operating mechanical equipment in Minnesota school buildings is valued at approximately one-half billion dollars, the savings that would be realized could easily justify this expenditure. In addition to the possibility of reducing maintenance expenses, other intangible benefits would result: for example, fewer interruptions to teachers, more comfortable environment to enhance the learning process, etc.

## 2. Establish Training Programs.

Preparatory and supplementary (on-the-job) training programs are needed to prepare the maintenance men to carry out an effective maintenance program. Operating mechanical equipment items related to heating systems are causing the most trouble, and the people responsible for their maintenance believe that they would benefit by further training in heating system technology. Of course, all items of OME must be studied to ensure their proper maintenance.

The new preparatory vocational training program presently being developed by the State Department of Education is well timed and badly needed. Other training programs also should be established. In addition to the necessary mechanical knowledge required for operating mechanical equipment, maintenance trainees should also be taught the basic essentials of a good preventive maintenance program -- the curriculum should include such items as inventory and location of equipment, planning and scheduling the work, following standardized operations and maintenance procedures, and maintaining an adequate system of records.

Consideration should be given, at both the state and district levels, to providing two basic training programs, namely, a formal pre-job training program and a formal on-the-job training program. On-the-job training programs can be further sub-divided into ones in which the training is provided during on-duty and off-duty time. Another objective of the training programs should be to develop a list of resource people, available on a free or fee basis, that could be called upon to assist local districts in solving particular problems.

It would probably be best to coordinate the training programs by using the Minnesota planning areas and the Area Vocational Schools.

### 3. Prepare A Maintenance Procedure Manual.

This manual should include detailed procedures for planning and implementing an effective program of school building maintenance procedures. As a minimum, the following topics should be included:

- Inventory of plant
- Planning and scheduling of work
- Standardized operation and maintenance procedures
- On-the-job training procedures
- Record keeping
- Program for review of records, schedules, and reporting of accomplishments

If all school districts were to use this manual, the maintenance procedures would be upgraded and standardized throughout the state. The effectiveness of the state-level engineering staff would be increased and the training activities of the vocational schools could be coordinated with on-the-job training procedures described in the manual.

# INTRODUCTION

With the ever-increasing demands for improved educational facilities, new school construction is proceeding rapidly, and procedures for operation and maintenance of operating mechanical equipment in these structures are becoming more complex. It is estimated that over ten percent of the national school budget is spent for the maintenance and operation of school facilities(1)*. A compilation of prime contract costs for school construction in Minnesota during the last fifteen years(2) shows that 19,804 classrooms were built at a total cost of approximately 832 million dollars. It is estimated that 36,150 classrooms are presently in existence in the state(2). Using the average construction cost per classroom during the last fifteen years ($42,000), this indicates that the replacement cost for all school buildings in Minnesota is 1.5 billion dollars. Because construction costs are continually rising, this estimate is considered conservative. Furthermore, since operating mechanical equipment in school buildings accounts for one-third of their cost(2), the OME in Minnesota school buildings can be valued at 500 million dollars. Because of this large amount of capital invested in OME, the economic necessity of maximizing the useful life of each piece of OME is obvious.

Recent evidence indicates that proper operation and maintenance of the complicated mechanical equipment found in the new school buildings require a level of competence that, in many cases, is beyond the abilities of the custodial engineers responsible for these duties. Several instances of failure of the heating equipment, requiring closing down of the schools, have been reported. Spot checks of school buildings and conferences with custodial engineers have uncovered discrepancies between the general conditions of the OME and operational procedures utilized. Some serious accidents have happened that might have been prevented had the operating personnel received proper training. Numerous examples of improper installation and maintenance practices have been observed over the years such as exhaust fans running backwards, roof exhaust fans that were never connected to motors, broken drive belts with motors running at full speed, etc.

In today's modern buildings, the operation of various OME items, such as heating and ventilating systems, is becoming more and more automatic, and the need for maintenance is many times overlooked until a breakdown occurs. In many cases, the causes for the failures are too readily attributed to weaknesses in design of equipment when, in reality, the actual cause can be attributed to poor maintenance practices or lack of training. As the operating mechanical equipment becomes more complex, it is becoming essential that more emphasis be placed on maintenance and operating procedures if maximum utilization and minimum operating costs are to be realized.

School systems presently have a three-month "down time" during the summer in which many of the maintenance tasks are performed. However, there is a growing emphasis on utilization of school buildings in the evenings and during the summer months. With increased summer usage of schools, many maintenance tasks that are presently handled during the summer months will have to be scheduled throughout the school year.

Years ago, most maintenance was carried out according to a "breakdown" procedure. In this method, a system is allowed to operate, along with gradual deterioration, until a failure occurs; at that time, all possible efforts are expended to put the system back into operation. Because of the life-and-death necessity of having properly maintained equipment, preventive maintenance procedures were developed for use by military maintenance organizations. In recent years, preventive maintenance procedures have been adopted by industry, and have also been used for many years by the airlines. Basically, a preventive maintenance program consists of a planned and controlled program of inspections, adjustments, repairs, and analysis of performance, designed to keep a system operating at peak efficiency. In anticipation of the ordinary wear that takes place when equipment is used, a process of continual periodic inspection and replacement of components takes place. If applied properly, a preventive maintenance program prevents unexpected or disabling failures, and greater system reliability results.

Because of staff shortages and limited allocated funds, many school maintenance programs still operate according to a breakdown procedure. When equipment is new, this type of maintenance probably can be accomplished at lower cost than if a preventive program were followed, but in the long run, the risks are greater and the ultimate costs are higher.

Industry has found that a well-controlled preventive maintenance program can result in many benefits(3). Some are:

- Greater system reliability
- Fewer large-scale repairs at less frequent intervals
- Extension of useful equipment life
- Minimization of standby equipment required
- Identification of causes of breakdowns and areas of weakness
- Better control of spare parts and smaller inventory

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*Superscripts refer to literature references at the end of the report.

- Maintenance of operating efficiency
- Easy determination of the time when equipment replacement is economical
- Leveling out of maintenance workload

In schools, additional benefits can be obtained, such as:

- Reduced interruptions in the educational function of the school
- Reduced lost time for teachers, administrative and clerical staff

Many of the benefits listed above can be related directly to reduced operation and maintenance costs. Although evidence of the savings that can result in following a well-managed and controlled preventive maintenance program is limited, industry has found that maintenance costs for OME can be reduced by as much as 25 percent(3). Currently, annual repair, replacement, and maintenance costs in Minnesota school buildings amount to 11.5 million dollars(2). If one uses the 25-percent savings found in industry, an annual savings of 2.9 million dollars would be realized. This estimate may be high because of some basic differences between industry and educational institutions. However, annual maintenance savings of 2 - 2.5 million dollars may be possible in Minnesota school buildings.

Although authorities differ on what constitutes a good preventive maintenance program, typical requirements are:(3)

- Good management maintenance policies
- An inventory of the plant equipment
- Planned and scheduled work
- Standardized operation and maintenance procedures
- Trained personnel
- Adequately tooled personnel
- An adequate system of records
- Program for review of records, schedules, and reporting of accomplishments

Recognizing the importance of proper maintenance of equipment in school buildings, the School Plant Planning Section of the State Department of Education, under the direction of Mr. Guy O. Tollerud, has long been interested in upgrading the quality of the maintenance procedures followed in Minnesota school buildings. The urgent need for a study that would determine the condition of operating mechanical equipment and the maintenance procedures in use was brought to the attention of the Louis W. and Maud Hill Family Foundation and North Star Research and Development Institute early in 1967. With financial support provided by the Hill Family Foundation, North Star initiated a research program on April 19, 1967. The objective of the program was to study and analyze the operation and maintenance procedures for OME in Minnesota school buildings. Such items as burners, unit ventilators, fans, dishwashers, air conditioners, refrigerators, clock systems, and public address systems were to be included in the study.

# QUESTIONNAIRE PHASE

## Objectives and Content of Questionnaires

The most reliable method of obtaining information about maintenance procedures would be to visit and inspect every public school building in the state. Needless to say, this would be extremely expensive, beyond the scope of the current program. Following a more reasonable procedure, it was decided that a series of well-planned questionnaires could provide valuable information about maintenance procedures and practices.

The objective of the questionnaires was to provide information on the following:

- Frequency of various types of maintenance
- Condition of OME in each school building
- Types of OME housed in the school
- Existence or non-existence of maintenance schedules and records
- Types of OME that are not functioning properly
- Physical characteristics of the school building
- Type and extent of maintenance training provided to the maintenance staff
- Educational and employment background of the head maintenance man
- Type of maintenance program utilized in the school district

In addition, it was believed that several subjective questions should be asked to establish the opinions of individuals concerned with equipment maintenance.

Obviously, it would have been impossible for one individual to provide all of the information desired for the schools in a district. Further, some of the data is normally kept on file in the school district office, while other data would be most readily obtained at each school. To obtain the desired information, the following questionnaires were prepared, each to be answered by different individuals:

- School Building Maintenance Questionnaire
- School Building General Information Questionnaire
- Personnel Information Questionnaire
- Local School District Questionnaire

The content of the questionnaires, along with the responses obtained, are discussed in detail later in this report.

## Distribution of Questionnaires and Responses Received

The distribution of all questionnaires was handled through the local school district offices. The Minnesota Educational Directory, 1966-1967, was used to ascertain the number of schools in each district. In addition to the Local School District Questionnaire, a group of packets (one for each school) was mailed to each district superintendent. Each packet contained a School Building Maintenance Questionnaire, a School Building General Information Questionnaire, and a Personnel Information Questionnaire. Instructions for completing each questionnaire were included in the packet. To ensure that the individual replies to the School Building Maintenance Questionnaire would be kept confidential, and to assure the head custodian of this fact, an envelope was provided in which his completed questionnaire was to be sealed before returning it to the District Office for forwarding, unopened, to North Star.

The packets were mailed during the week of July 17, 1967, and the rate of return of the completed questionnaires is shown in Figure 1. There was a high initial response during the first three weeks following the mailing, but returns dropped off during the fourth, fifth, and sixth weeks. Consequently, a follow-up letter requesting that the questionnaires be returned as soon as possible was mailed during the sixth week to those districts that had not yet replied. As can be noted from Figure 1, this resulted in an increased response during the seventh, eighth, and ninth weeks. The number of replies dropped off considerably during the tenth through thirteenth weeks, and it was decided to send a second follow-up letter to the delinquent districts. This letter was mailed during the thirteenth week and resulted in an increased response rate during the fourteenth through seventeenth weeks. By the end of the twentieth week

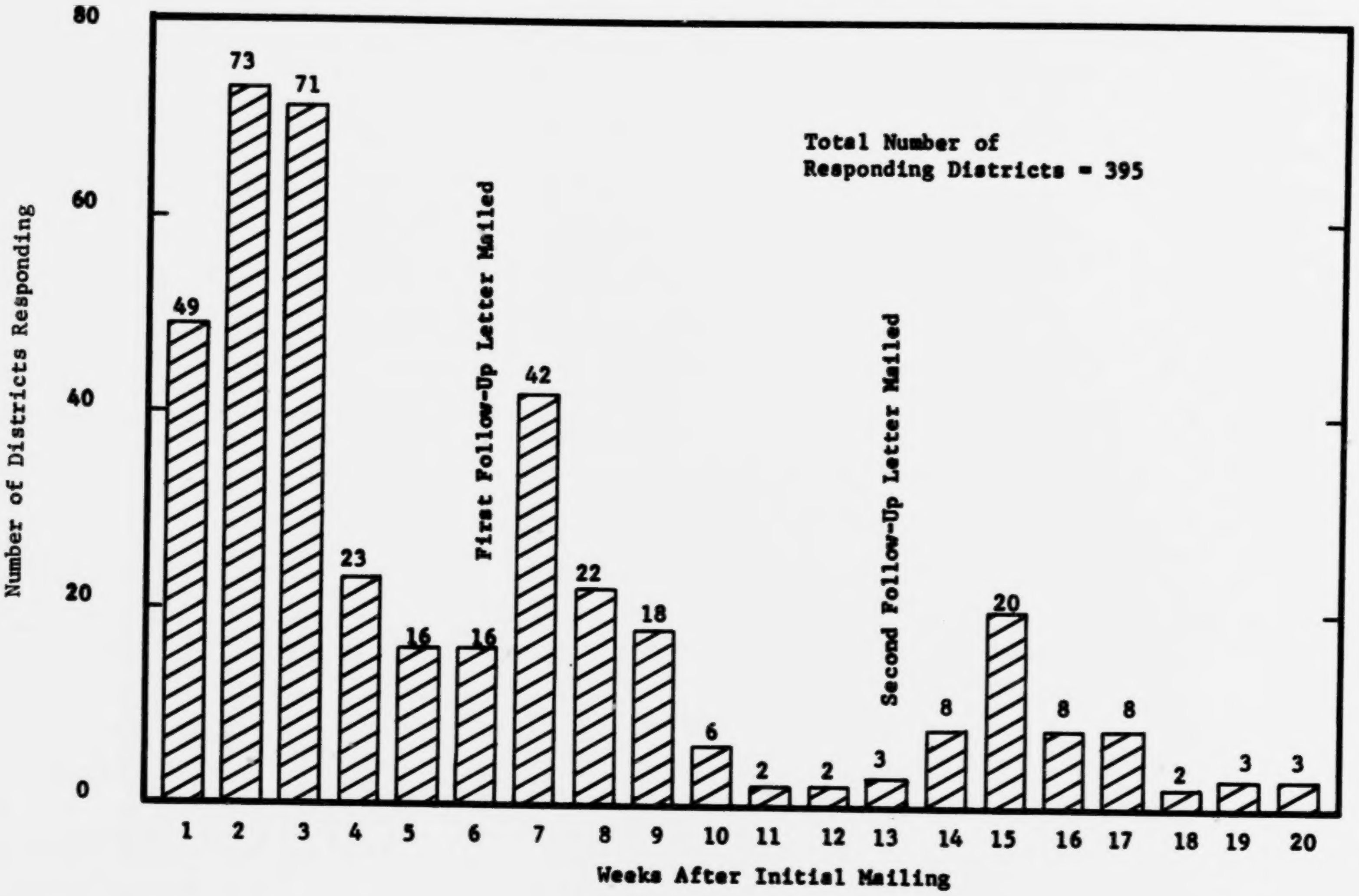


FIGURE 1. RETURN OF COMPLETED QUESTIONNAIRES

after the initial mailing, replies had been received from 395 districts, representing approximately 83 percent of the districts in the state. It was decided that this constituted a suitably large sample and no more follow-up letters would be sent to the districts that had not responded.

During the course of the study, it was found that most of the districts with two schools listed in the Minnesota Educational Directory had only one school building that housed both the elementary and secondary grades. The total number of schools listed in the directory (1,778), therefore, must be reduced by a certain amount to establish the number of school buildings in the state. Based on the tabulations in the directory, returned questionnaires, and estimates for the remaining two- and three-school districts, it can be estimated that approximately 1,480 school buildings in the state received the questionnaires. This number was, therefore, used in determining the percentage of returns for the three school questionnaires indicated in Table 1.

TABLE 1

SUMMARY OF RESPONSES TO QUESTIONNAIRES

| Questionnaire | Number of Replies | Percentage of Total Possible Replies |
|---|---|---|
| School Building Maintenance | 1180 | 79.8 |
| School Building General Information | 1130 | 76.5 |
| Personnel Information | 1057 | 71.4 |
| Local School District | 368 | 77.3 |

The average response for all four questionnaires was about 76 percent. Complete sets of all three questionnaires (School Building Maintenance, School Building General Information, and Personnel Information

Questionnaires) were received from 964 school buildings (65.1 percent). Thus, the questionnaire portion of this study resulted in complete information for approximately 65 percent of the school buildings and at least partial information for about 80 percent of the buildings.

## Computer Analysis of Returned Questionnaires

Because of the large number of questionnaires to be analyzed, the replies were transferred to computer cards, and a computer analysis was performed. Questions of a subjective nature were not included in the computer analysis, but were tabulated by hand.

There is some possibility of errors occurring in transcribing the data from the questionnaires to the computer cards. To estimate these probable errors, 200 cards were selected at random and checked by comparing them with the transcription sheets. Only 25 errors out of 16,000 entries were found, indicating that only 0.156 percent of the transcriptions were in error.

Because the preceding analysis was based on only a portion of the computer cards, standard statistical methods were employed to establish a 95-percent confidence interval. The results indicate that one can be 95 percent confident that the transcription error lies between 0.075 and 0.238 percent error. In other words, we are 95 percent confident that the transcription error is at least 0.075 percent, but not larger than 0.238 percent.

The UMSTAT 500 correlation and multiple linear regression analysis computer program, available at the University of Minnesota Computer Center, was used to analyze the information provided on the IBM cards. A Control Data Corporation 6600 digital computer was used to process the data. It was not necessary to utilize all portions of the program for the purposes of this study.

## Results of Questionnaires

All of the results and analysis that follow are based on the assumption that the questionnaires were filled out completely, accurately, and truthfully. Therefore, all conclusions are based on what the responder has said, and may not represent an entirely accurate picture of what the responder actually does.

The responses to each question in the questionnaires are discussed in detail in the following sections. For convenience and ready reference, copies of the questionnaires are also included.

### School Building Maintenance Questionnaire

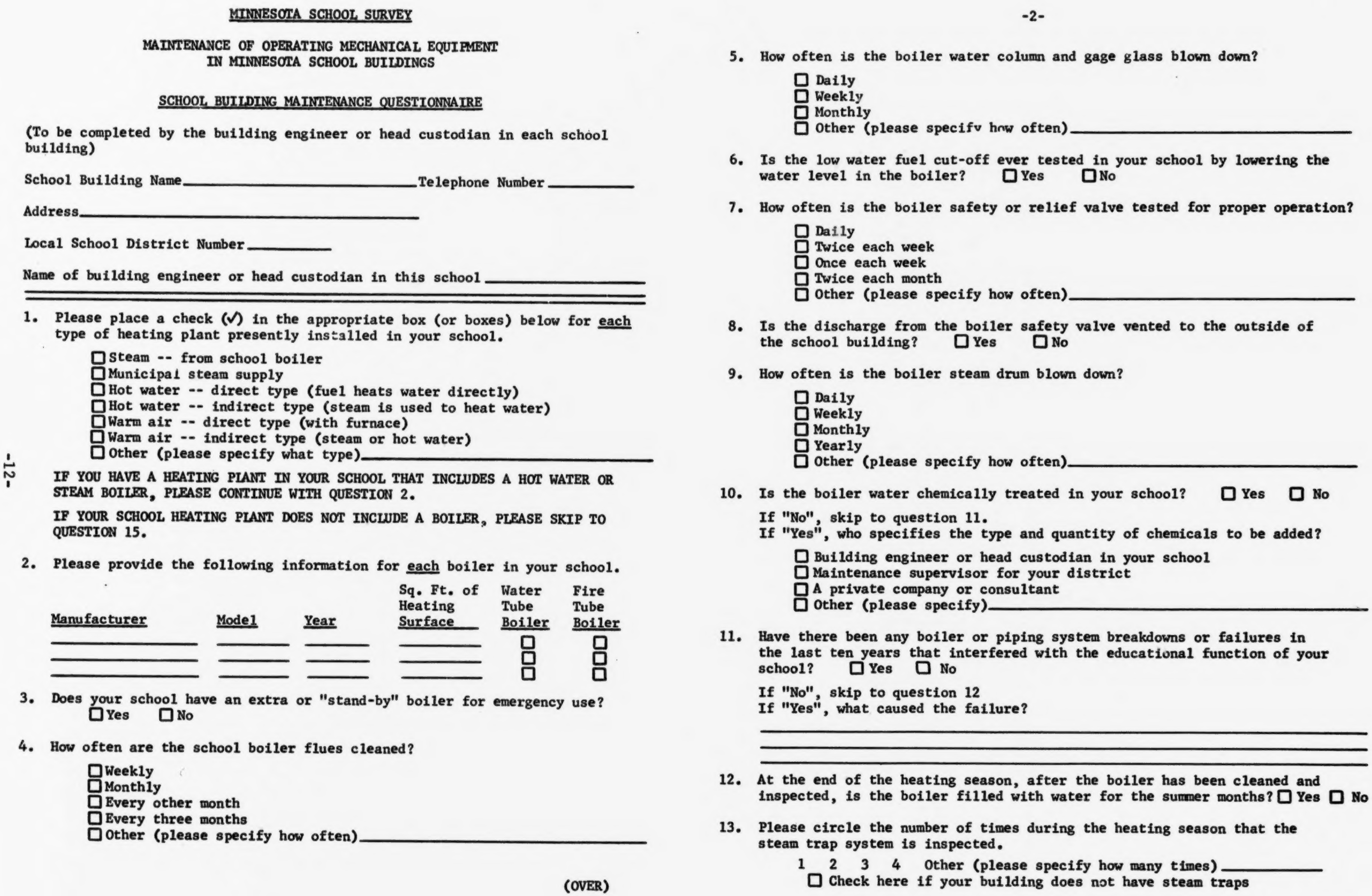
This questionnaire was to be completed by the building engineer or head custodian in each school building. Because the boiler room contains a significant portion of the OME in most school buildings, and since most buildings contain some type of boiler, a large portion of the questionnaire is concerned entirely with boiler maintenance procedures. Other questions dealing with the overall heating system, maintenance procedures, inoperative equipment, time spent on maintenance, and training requirements, are included. The questionnaire is shown in Figure 2.

Question 1. The total number of replies to the seven categories of heating plants exceeds the number of schools that returned this questionnaire (1,180) because many schools had two or more types of heating plants. The replies to this question are presented in Figure 3. About 86 percent of the schools use steam for heating, either from a school boiler or from a municipal steam supply. Non-steam systems are the direct hot water, direct warm air, and "other" categories. In the "other" category, nine schools were heated with steam from another building or central plant, five were heated electrically, and two had radiant floor heating.

Question 2. In this question, the requested information is of a background or informative nature pertaining to general boiler description. The replies to this question ranged from complete information about each boiler to no information at all. It was believed that questions of this type, although not of much significance by themselves, might be of value in assessing replies to other questions and estimating heating characteristics of a school building. In general, the policy has been to include relevant findings from this question at other points in this report.

Question 3. Of the schools that returned this questionnaire, 47 percent have an extra or "stand-by" boiler for emergency use, 43 percent do not, and 10 percent did not answer the question.

Question 4. In this question about the frequency of cleaning the boiler flues, a large number of individuals (403) checked "other". Therefore, the "other" replies were tabulated and are presented, along with the first four choices in this question, in Figure 4. The frequency of cleaning the boiler flues



MINNESOTA SCHOOL SURVEY

MAINTENANCE OF OPERATING MECHANICAL EQUIPMENT
IN MINNESOTA SCHOOL BUILDINGS

SCHOOL BUILDING MAINTENANCE QUESTIONNAIRE

(To be completed by the building engineer or head custodian in each school building)

School Building Name________________ Telephone Number__________

Address______________________

Local School District Number__________

Name of building engineer or head custodian in this school__________

1. Please place a check (✓) in the appropriate box (or boxes) below for each type of heating plant presently installed in your school.
   - ☐ Steam -- from school boiler
   - ☐ Municipal steam supply
   - ☐ Hot water -- direct type (fuel heats water directly)
   - ☐ Hot water -- indirect type (steam is used to heat water)
   - ☐ Warm air -- direct type (with furnace)
   - ☐ Warm air -- indirect type (steam or hot water)
   - ☐ Other (please specify what type)__________

IF YOU HAVE A HEATING PLANT IN YOUR SCHOOL THAT INCLUDES A HOT WATER OR STEAM BOILER, PLEASE CONTINUE WITH QUESTION 2.

IF YOUR SCHOOL HEATING PLANT DOES NOT INCLUDE A BOILER, PLEASE SKIP TO QUESTION 15.

2. Please provide the following information for each boiler in your school.

| Manufacturer | Model | Year | Sq. Ft. of Heating Surface | Water Tube Boiler | Fire Tube Boiler |
|---|---|---|---|---|---|
| | | | | ☐ | ☐ |
| | | | | ☐ | ☐ |
| | | | | ☐ | ☐ |

3. Does your school have an extra or "stand-by" boiler for emergency use?
   ☐ Yes ☐ No

4. How often are the school boiler flues cleaned?
   - ☐ Weekly
   - ☐ Monthly
   - ☐ Every other month
   - ☐ Every three months
   - ☐ Other (please specify how often)__________

(OVER)

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5. How often is the boiler water column and gage glass blown down?
   - ☐ Daily
   - ☐ Weekly
   - ☐ Monthly
   - ☐ Other (please specifv how often)__________

6. Is the low water fuel cut-off ever tested in your school by lowering the water level in the boiler? ☐ Yes ☐ No

7. How often is the boiler safety or relief valve tested for proper operation?
   - ☐ Daily
   - ☐ Twice each week
   - ☐ Once each week
   - ☐ Twice each month
   - ☐ Other (please specify how often)__________

8. Is the discharge from the boiler safety valve vented to the outside of the school building? ☐ Yes ☐ No

9. How often is the boiler steam drum blown down?
   - ☐ Daily
   - ☐ Weekly
   - ☐ Monthly
   - ☐ Yearly
   - ☐ Other (please specify how often)__________

10. Is the boiler water chemically treated in your school? ☐ Yes ☐ No

    If "No", skip to question 11.
    If "Yes", who specifies the type and quantity of chemicals to be added?
    - ☐ Building engineer or head custodian in your school
    - ☐ Maintenance supervisor for your district
    - ☐ A private company or consultant
    - ☐ Other (please specify)__________

11. Have there been any boiler or piping system breakdowns or failures in the last ten years that interfered with the educational function of your school? ☐ Yes ☐ No

    If "No", skip to question 12
    If "Yes", what caused the failure?

12. At the end of the heating season, after the boiler has been cleaned and inspected, is the boiler filled with water for the summer months? ☐ Yes ☐ No

13. Please circle the number of times during the heating season that the steam trap system is inspected.

    1 2 3 4 Other (please specify how many times)__________
    ☐ Check here if your building does not have steam traps

FIGURE 2. SCHOOL BUILDING MAINTENANCE QUESTIONNAIRE

14. Does your staff maintain a boiler log? ☐ Yes ☐ No

If "No", skip to question 15.
If "Yes", are boiler log entries made on a daily basis? ☐ Yes ☐ No

15. What type of fuel is used in your heating plant?

☐ Gas
☐ Oil -- Please give viscosity or grade ________
☐ Dual fuel system (oil and gas)
☐ Coal
☐ Other (please specify what type) ________

16. Please indicate how often the gas or oil burner flame is checked for proper shape and good combustion in your school boiler.

☐ Daily
☐ Weekly
☐ Every two weeks
☐ Monthly
☐ Other (please specify how often) ________
☐ No gas or oil burners

17. Is the combustion unit equipped with a photocell or flame-eye apparatus?

☐ Yes ☐ No

If "No", skip to question 18.
If "Yes", answer questions 17a and 17b.

17a. How often are the glass lenses of this unit cleaned?

☐ Daily
☐ Weekly
☐ Every two weeks
☐ Monthly
☐ Other (please specify how often)________

17b. How often are the electronic tubes in the flame-eye or photocell control replaced?

☐ Once each year
☐ Twice each year
☐ Only when they burn out
☐ Other (please specify how often)________

18. Is your school equipped with classroom unit ventilators? ☐ Yes ☐ No

If "No", skip to question 19.
If "Yes", answer 18a and 18b.

18a. Please circle the number of times the unit ventilator automatic controls are checked for proper operation each year.

1 2 3 4 Other (please specify how many times per year)________

☐ Check here if the unit ventilators do not have automatic controls.

18b. How often are the air filters in the ventilators cleaned or replaced?

☐ Weekly
☐ Monthly
☐ Every other month
☐ Every three months
☐ Other (please specify how often)________
☐ No air filters in unit ventilators

19. How often has it been necessary to replace hot water tanks or vessels in your school because of corrosion or scale?

☐ Never
☐ Every two years
☐ Every four years
☐ Every six years
☐ Other (please specify how often)________

20. Is your school equipped with any water softeners? ☐ Yes ☐ No

If "No", skip to question 21.
If "Yes", is the entire school water supply softened? ☐ Yes ☐ No

21. What is the water source for your school?

☐ Municipal water system
☐ School well
☐ Other (please specify)________

22. Please provide the following information for your school water system:

Grain hardness of water ________
Iron content of water ________

23. How often are exhaust fans and blowers located on the roof inspected and necessary adjustments made?

☐ No roof exhaust fans or blowers
☐ Twice each month
☐ Monthly
☐ Every three months
☐ Every six months
☐ Yearly
☐ Other (please specify how often)________

24. Is your school equipped with automatic dishwashers? ☐ Yes ☐ No

If "No", skip to question 25.
If "Yes", at what temperature is the water maintained?________

25. Is your school equipped with a sprinkler system for fires? ☐ Yes ☐ No

If "No", skip to question 26.
If "Yes", answer questions 25a and 25b.

FIGURE 2. (CONTINUED)

25a. Who inspects this system?

☐ A member of the school maintenance staff
☐ Local fire department
☐ Other (please specify) ______________

25b. Please circle the number of times the system is inspected each year.

1 2 3 4 Other (please specify how many times) ________

26. Please circle how many times toilet flushing mechanisms are adjusted each year.

1 2 3 4 Other (please specify how often) ______________

27. What type of temperature control system is installed in your school?

☐ Manual
☐ Pneumatic
☐ Electric
☐ None

If you checked pneumatic, how often is the compressor receiver tank drained of moisture?

☐ Daily
☐ Weekly
☐ Monthly
☐ Other (please specify how often) ______________

28. Do you keep an up-to-date file containing operating and maintenance instructions for each piece of operating mechanical equipment (see definition on last page) in your school? ☐ Yes ☐ No

If "Yes", skip to question 29.
If "No", are such instructions available to you from either the school principal's or district superintendent's offices? ☐ Yes ☐ No

29. Are records kept in your school that show what maintenance has been performed on operating mechanical equipment? ☐ Yes ☐ No

If "No", skip to question 30.
If "Yes", to whom are these records (or copies of them) sent?

☐ School Principal
☐ District Maintenance Supervisor
☐ District Superintendent
☐ Other (please specify to whom) ______________
Title

30. Is your staff provided with a master maintenance schedule that tells how often each piece of operating mechanical equipment (see definition on last page) should be inspected? ☐ Yes ☐ No

31. Does your school have a master list (or map) that describes where in the school building each piece of operating mechanical equipment is located.

☐ Yes ☐ No

32. Many items frequently found in public schools are listed below. You will note that three boxes are placed before each item. If the maintenance of an item is on a preventive basis, check the first box. If on a breakdown basis, check the second box. Please check the third box if the maintenance of this item is performed by a company or individual who is not a school system employee (for example, an outside contractor). If your school does not have the listed item, please draw a line through that item.

| Preventive Maintenance | Breakdown Maintenance | Check here if maintenance is performed by outside contractor | |
|---|---|---|---|
| ☐ | ☐ | ☐ | Refrigerators |
| ☐ | ☐ | ☐ | Domestic hot water system |
| ☐ | ☐ | ☐ | Hot water heaters |
| ☐ | ☐ | ☐ | Booster heaters |
| ☐ | ☐ | ☐ | Dishwashing machines |
| ☐ | ☐ | ☐ | Drinking fountains |
| ☐ | ☐ | ☐ | Faucets |
| ☐ | ☐ | ☐ | Flushometer valves |
| ☐ | ☐ | ☐ | Gas Burning equipment |
| ☐ | ☐ | ☐ | Unit ventilators |
| ☐ | ☐ | ☐ | Oil burning equipment |
| ☐ | ☐ | ☐ | Steam traps |
| ☐ | ☐ | ☐ | Roof drains |
| ☐ | ☐ | ☐ | Grease traps |
| ☐ | ☐ | ☐ | Showers |
| ☐ | ☐ | ☐ | Air Filters |
| ☐ | ☐ | ☐ | Window and door hardware |
| ☐ | ☐ | ☐ | Exhaust fans |
| ☐ | ☐ | ☐ | Electric motors |
| ☐ | ☐ | ☐ | Pneumatic control systems |
| ☐ | ☐ | ☐ | Pumps |
| ☐ | ☐ | ☐ | Steam distributing systems |
| ☐ | ☐ | ☐ | Boiler controls |
| ☐ | ☐ | ☐ | Clock system |
| ☐ | ☐ | ☐ | Fire alarm systems |
| ☐ | ☐ | ☐ | Public address system |
| ☐ | ☐ | ☐ | Boilers |
| ☐ | ☐ | ☐ | Water softeners |
| ☐ | ☐ | ☐ | Sewage disposal system |
| ☐ | ☐ | ☐ | Converters or heat exchangers |
| ☐ | ☐ | ☐ | Cooling towers |
| ☐ | ☐ | ☐ | Air compressors |
| ☐ | ☐ | ☐ | Air conditioners |

33. Please list below each piece of operating mechanical equipment in your school that is not operating because it is out of repair.

______________ ______________ ______________
______________ ______________ ______________

FIGURE 2. (CONTINUED)

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34. Please list below the major operating mechanical equipment that gives you or your staff the most problems or difficulties.

35. Does your staff maintain records that show how much of their daily work time is spent on maintenance of operating mechanical equipment?

☐ Yes ☐ No

36. What are the total number of man-hours per week spent on the maintenance of operating mechanical equipment in your school?

______Total man-hours per week

37. How many man-hours per week do you feel are necessary to properly maintain the operating mechanical equipment in your school?

______Man-hours per week.

---

North Star is interested in finding out if additional advanced training in the operation and maintenance of mechanical equipment would be helpful to you and your staff in the performance of your job. Please answer the following questions. We want to emphasize, once again, that all replies will be kept in the strictest confidence.

38. Do you believe that additional advanced training would help you in the performance of your job? ☐ Yes ☐ No

39. Do you believe that additional advanced training would help your staff in the performance of their jobs? ☐ Yes ☐ No

---

Assume that a brief, free, training program were offered that provided advanced instruction on the operation and maintenance procedures for school building mechanical equipment. Please answer the following questions.

40. If attendance were required by your school or school district, when would you prefer to have the course held?

☐ During the school year
☐ During the summer vacation period.

If you checked "summer vacation period", skip to question 41.
If you checked "school year", what part of the week would you suggest for holding the course?

☐ During the school day
☐ On weekday evenings
☐ On weekends

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41. If attendance were not required by your school or school district, please check the one statement in each group below that best describes your feelings.

a. If the course were held during working hours,

☐ I would definitely attend
☐ I would probably attend
☐ I would probably not attend
☐ I would definitely not attend

b. If the course were held during "off-duty" hours,

☐ I would definitely attend
☐ I would probably attend
☐ I would probably not attend
☐ I would definitely not attend

42. Briefly, on what type of equipment would you like to have advanced instruction in such a training program? (You may wish to use question 32 as a guide or subject outline.)

43. Please add any additional comments or suggestions pertaining to your job, working conditions, desired training, etc.

---

**Definition:** Operating Mechanical Equipment -
Equipment having moving parts that are actuated by a power source; for instance, unit ventilators, heating and ventilating control systems, clock and bell systems, elevators, refrigeration systems, electric motors, automatic dishwashers, garbage disposers, etc.

Prepared by:
NORTH STAR RESEARCH AND DEVELOPMENT INSTITUTE

FIGURE 2. (CONTINUED)

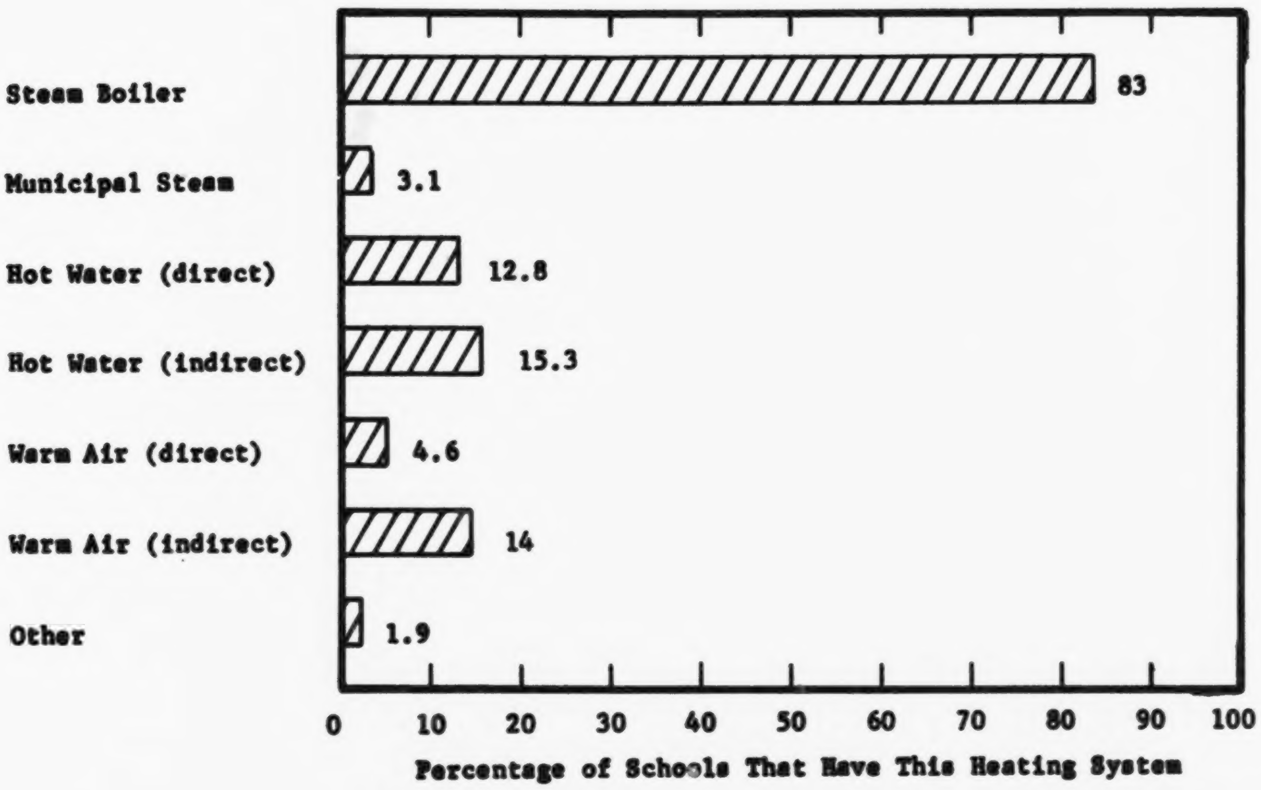

FIGURE 3. TYPES OF HEATING SYSTEMS USED IN SCHOOL BUILDINGS

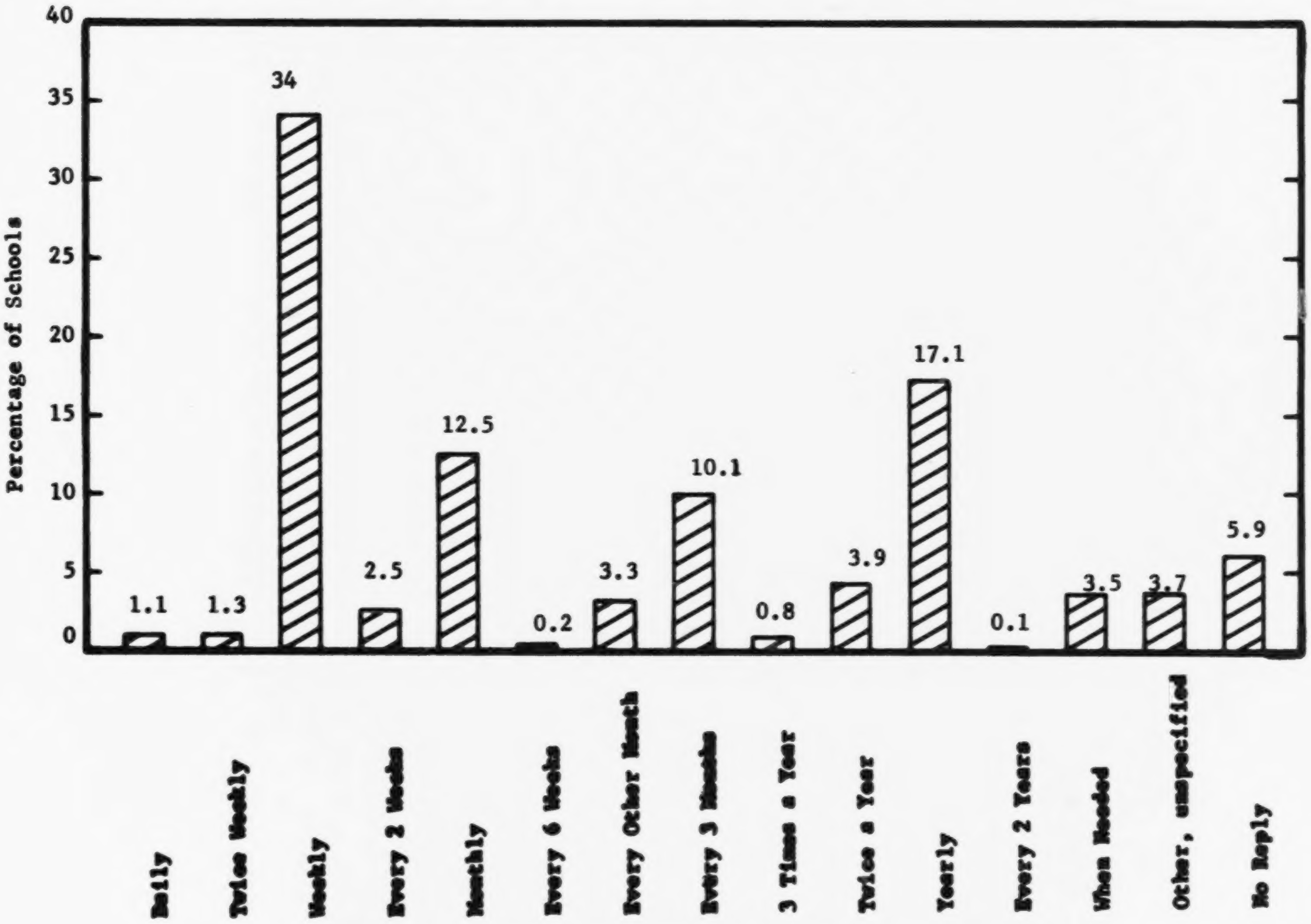

FIGURE 4. FREQUENCY OF CLEANING BOILER FLUES IN SCHOOL BUILDINGS

depends, to a great extent, on the type of fuel used. When coal is used, the flues should be cleaned frequently, perhaps daily or once a week. Gas-fired boilers usually are very clean, and the flues require cleaning only once or twice a year. Of the 212 buildings that use coal, the flues are cleaned weekly in 75 percent of the schools, monthly in six percent, every other month in two percent, and every three months in six percent. Eleven percent indicated other frequencies of cleaning. The "other" categories were not individually analyzed in the computer program. However, even if all of those that checked "other" performed this task twice a week, at least 14 percent of the schools using coal do not clean the flues frequently enough.

Question 5. The water column and gage glass is blown down daily in 70 percent of the schools, weekly in 16 percent, and monthly in 1.5 percent. 3.3 percent indicated "other" and 9.2 percent did not answer the question. The replies of those that checked "other" ranged from twice daily to three times each year. Various authorities suggest that this task be performed on a weekly(3) or daily(4) basis.

Question 6. According to Reference 5, the low water fuel cut-off should be tested twice each week by lowering the water level in the boiler. Of the questionnaires returned from schools with a steam boiler (980), 85 percent said they do test the low water fuel cut-off in this manner, 6 percent said they did not, and 9 percent did not reply to the question. This indicates that in at least six percent (but in no more than 15 percent) of the schools that have a boiler, the recommended testing of the low water fuel cut-off is not performed at all, let alone twice weekly.

Question 7. According to References 4 and 5, the boiler relief valve should be tested on a daily basis. Of those schools that have a steam boiler, 44 percent indicated that this check was performed daily, 12 percent indicated twice each week, 24 percent said once each week, 10 percent replied twice each month, 8 percent checked "other", and 2 percent did not answer the question. Of those schools that have a direct-type hot water boiler, 39 percent indicated daily, 13 percent said twice each week, 26 percent stated once each week, 9 percent said twice each month, 9 percent checked "other", and 4 percent did not answer the question. It, therefore, appears that only about 44 percent of the schools with steam or hot water boilers perform this test according to the recommended schedule. Of those individuals that indicated "other", the answers ranged from three times each week to "never".

Question 8. Frequently, individuals in charge of boilers that do not have the discharge from the safety valve vented to the outside are reluctant to check the boiler safety valve because of the steam that is allowed to enter the boiler room. Of those buildings that have a steam boiler, 6.5 percent have the discharge vented to the outside, and 89 percent do not; 4.5 percent did not answer this question.

Question 9. According to Reference 5, the steam drum or boiler proper should be blown down at least once each week. Of those schools that have a steam boiler, 34.5 percent perform this operation on a daily basis, 33 percent on a weekly basis, 8.5 percent on a monthly basis, and 3 percent on a yearly basis. Ten percent checked "other", and 11 percent did not respond. Of those individuals that checked "other", typical frequencies of twice each day, twice each year, whenever necessary, and "never" were reported. From these data, at least 12 percent of the schools with steam boilers do not follow recommended blow-down schedules, and at least 68 percent do.

Question 10. Ninety-three percent of the school buildings have some form of chemical treatment of the boiler water, five percent do not, and two percent did not reply. Of those schools that have a boiler water treatment program, the type and quantity of chemicals is specified by the building engineer in 30 percent of the schools, by the district maintenance supervisor in 29 percent of the schools, by a private company or consultant in 37 percent of the schools, and by "other" in four percent of the buildings.

Question 11. Three percent of the schools have had piping system breakdowns within the last ten years, 88 percent have not, and 9 percent did not reply. Of the buildings that reported such breakdowns, a variety of causes were reported. In one school building, pipes located in the concrete floor became badly rusted and required replacement. Two schools reported problems with unit ventilators and radiator freeze-ups. Two schools reported problems because of improper water treatment. One school reported that all of the boiler tubes had to be replaced because of a poor batch of oil. Another building reported failure of pipe insulation that caused exterior deterioration of steam lines.

Question 12. Twenty-four percent of the schools utilize a "wet" lay-up for the boiler during the summer, 64 percent use a "dry" lay-up, and 12 percent did not reply.

Question 13. Of those schools that contain a steam boiler, 33 percent inspect the steam trap system once each year, 21 percent check it twice each year, 7 percent say three times per year, 10 percent report four times, 16 percent checked "other", 6 percent did not have traps, and 7 percent gave no reply. Of those who checked "other", 30 said "when necessary", one said monthly, one said weekly, and one said daily.

Question 14. The maintenance of a boiler log can be important in helping to keep the heating system at peak efficiency. Changes that are noted from a boiler log often indicate a pending problem, allowing the operator to take appropriate action to minimize problems and breakdowns.

Of those schools with a steam boiler, 29 percent maintain a boiler log, 55 percent do not, and 16 percent did not answer the question. Of those individuals maintaining a log, 66 percent make daily entries and 34 percent do not.

Question 15. Six percent of the school buildings use gas for fuel, 31 percent use oil, 40 percent have a dual fuel system, 15 percent use coal, 3 percent use a combination of gas, oil, and coal, 1 percent checked "other", and 4 percent did not answer.

Question 16. According to Reference 3, the gas or oil burner flame should be checked daily for proper shape and good combustion. The replies to this question indicate that the flame is checked daily in 53 percent of the schools, weekly in 14 percent, every two weeks in 2 percent, monthly in 6 percent, and "other" in 5 percent. Seven percent said they did not have gas or oil burners, and 13 percent did not reply to the question. Of those who checked "other", 15 said "when necessary", 18 said yearly, and 12 gave responses ranging from four times a day to twice each year. Based on the replies of those who have an oil or gas burner and answered this question, about 66 percent follow the recommended schedule.

Question 17. The combustion unit is equipped with a flame-eye apparatus in 71 percent of the schools, it is not in 15 percent of the buildings, and 14 percent did not reply. It is recommended that the lenses of the photocell unit be cleaned weekly(3). Of those that have such a unit, 17 percent clean the lenses daily, 41 percent weekly, 9 percent every two weeks, 22 percent monthly, and 11 percent checked "other". Of those checking "other", 46 said "when necessary", 14 said "yearly", and 14 gave replies ranging from "twice weekly" to "twice yearly". Therefore, about 58 percent of the respondents follow the recommended procedure.

It is recommended that the electronic tubes in the flame-eye control be replaced on a yearly basis(3). Of those schools in which such controls are installed, only 30 percent follow this advised replacement frequency, 2 percent of the schools indicated twice each year, 57 percent checked "only when they burn out", and 11 percent checked "other". Of the 89 people checking other, 70 said "when needed", which is probably equivalent to "when they burn out". Thus, it can probably be assumed that the tubes are replaced only when they burn out in 65 percent of the schools. Of those who checked "other", six people indicated frequencies ranging from once every two years to once every ten years, and one individual said "never".

Question 18. Eighty percent of the school buildings are equipped with unit ventilators and 20 percent are not. Of those buildings with unit ventilators, the automatic controls are checked for proper operation once each year in 27 percent of the schools, twice each year in 34 percent of the buildings, three times each year in 13 percent, four times per year in 13 percent, and 10 percent of the replies indicated "other". In three percent of the buildings, the units are not equipped with automatic controls.

Thirty-four percent of those answering Question 18b checked "other". A tabulation of these replies has, therefore, been included in the analysis, and the total range of answers is presented in Figure 5. Unit ventilator air filters should be cleaned or replaced at least every three months(6). Figure 5 shows that approximately 60 percent of the schools meet or exceed this recommendation.

Question 19. When asked how often hot water storage tanks were replaced, a significant portion (18 percent) of the respondents checked "other". The replies were, therefore, tabulated by hand and are presented in Figure 6. At worst, a well-maintained hot-water storage tank should last at least 15 years. Thus, it appears that hot water tanks in approximately ten percent of the buildings are not adequately maintained. From the computer, it was possible to determine the average number of years since construction for those schools that answered this question. For instance, those schools checking "never" were constructed, on the average, 17 years ago. Those schools checking some frequency of replacement (2, 4, 6 years and "other") were constructed, on the average, 27 years ago. Thus, the schools that answer "never" tend to be, on the average, ten years newer than those indicating some frequency of replacement.

The average grain hardness of water in schools that have never replaced hot water tanks is 7.5, and in schools that have replaced tanks, 8.9. This shows only a slight correlation between hardness of water and frequency of replacement of hot water tanks.

Question 20. Twenty-six percent of the schools are equipped with water softeners, 67 percent are not, and 7 percent did not answer. Of those schools equipped with softeners, 23 percent have the entire school water supply softened, and 77 percent do not. The schools with water softeners have an average grain hardness of 11.5, and those without have 6.1.

Of the schools with softeners, 73 percent have never replaced hot water tanks, 23 percent have, and 4 percent did not answer. Of the schools without softeners, 70 percent have never replaced hot water tanks, 24 percent have, and 6 percent did not answer. Thus, there is no significant difference in frequency of replacement between schools with and without water softeners.

Question 21. Eighty-three percent of the schools obtain water from a municipal system, 16 percent from a school well, and 1 percent indicated "other". One individual who checked "other" indicated that the water source for the school was "boiler water".

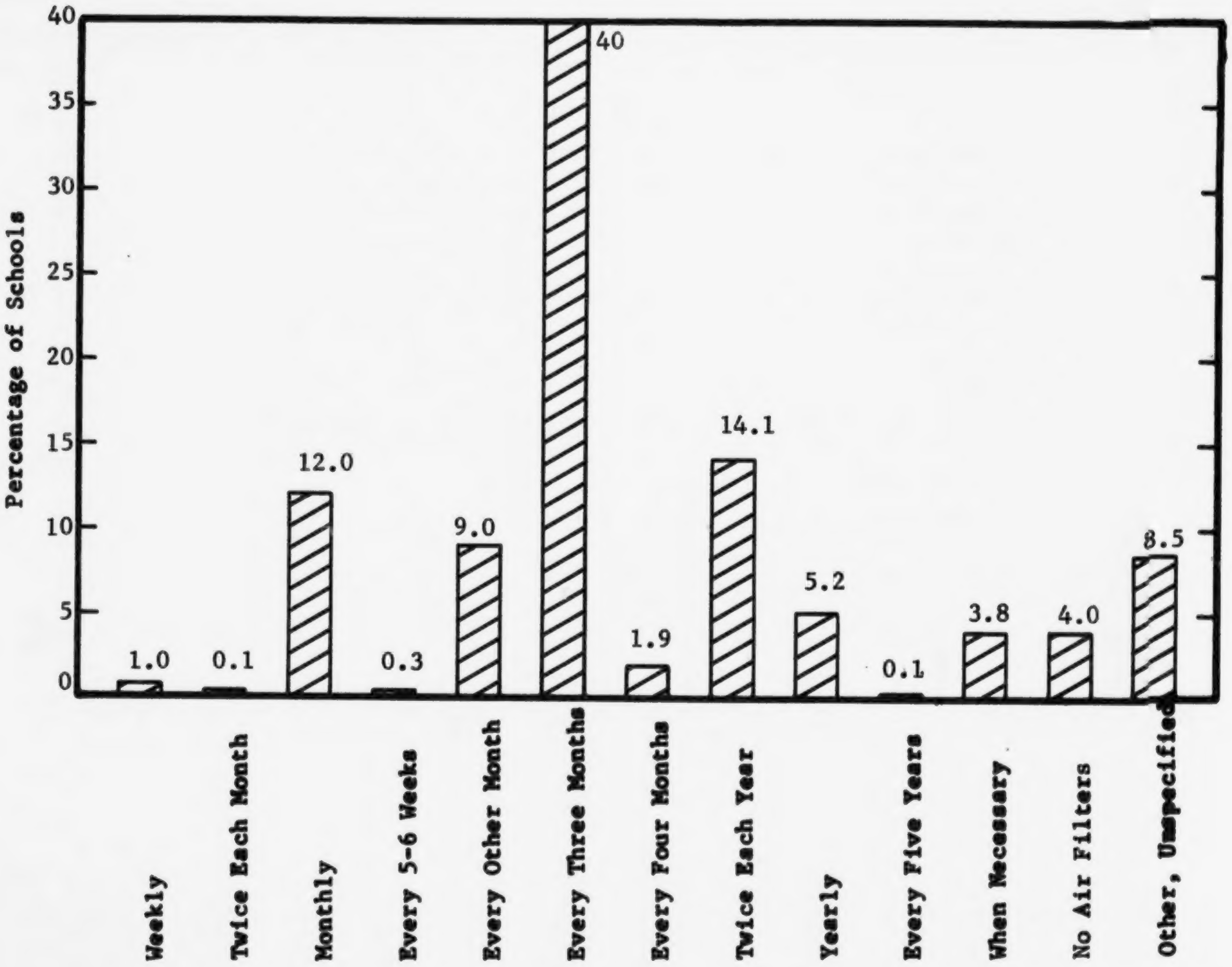

FIGURE 5. FREQUENCY OF CLEANING OF UNIT VENTILATOR FILTERS IN SCHOOL BUILDINGS

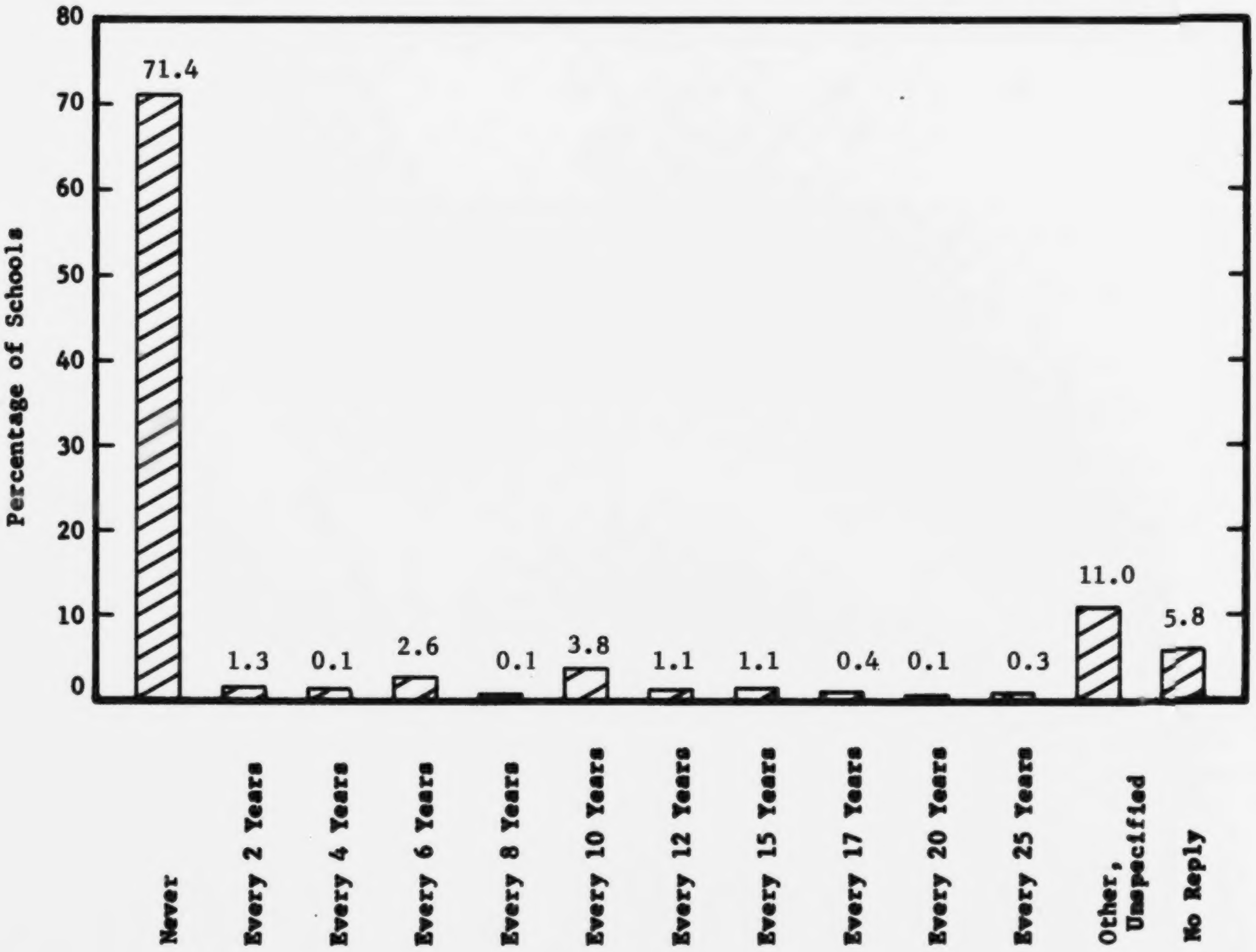

FIGURE 6. FREQUENCY OF REPLACEMENT OF HOT WATER STORAGE TANKS IN SCHOOL BUILDINGS

Question 22. A large number of replies did not include the grain hardness and an even larger portion did not give the iron content. The data returned did, however, provide information that proved useful for cross-correlation purposes, such as for Question 19 and 20.

Question 23. Eleven percent of the schools reported that they did not have roof exhaust fans, and three percent did not reply. Of those that did reply, 4.5 percent said that roof exhaust fans are inspected twice each month, 21 percent said monthly, 18.5 percent indicated every three months, 20 percent checked every 6 months, 31.5 percent said yearly, and 4.5 percent checked "other".

Question 24. Sixty-one percent of the schools are equipped with automatic dishwashers, 36 percent are not, and 3 percent did not answer the question.

Question 25. Eight percent of the schools are equipped with a sprinkler system for fires, 90 percent are not, and 2 percent did not answer. The schools not equipped with a sprinkler system, on the average, were about four years older than those with such a system. Requirements for sprinkling systems vary with local building codes.

Question 26. According to Reference 5, toilet flushing mechanisms should be adjusted four times each year to assure proper operation. A large number of the respondents (50 percent) checked "other". Of these, 81 percent said "when necessary". A summary of the replies is presented in Figure 7. Only about 8 percent of the schools follow the recommended frequency for adjustment. The 41 percent that said "when necessary" make adjustments only on a breakdown basis.

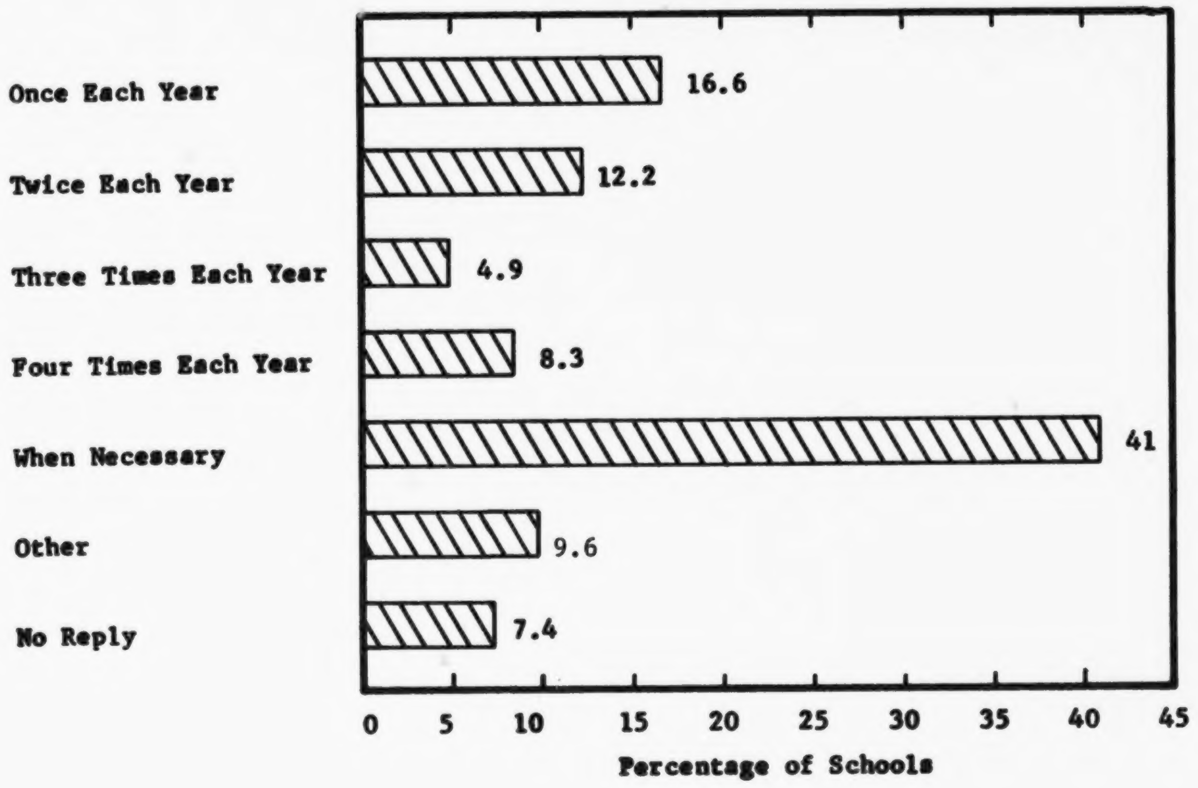

FIGURE 7. FREQUENCY OF ADJUSTMENT OF FLUSHING MECHANISMS IN SCHOOL BUILDINGS

Question 27. A number of schools are equipped with more than one type of temperature control system. The replies to this question are presented in Figure 8, which shows that the majority of schools are equipped with pneumatic control systems. Of those schools that have a pneumatic system, the compressor receiver tank is drained daily in 32 percent of the buildings, weekly in 46 percent, monthly in 16 percent, and "other" in 6 percent. It is commonly recommended that the tank be drained at least on a weekly basis, and this is not done in at least 16 percent of the buildings. If the tanks are not regularly drained, the pneumatic control lines can fill with water. It is impossible to clean out such flooded lines and they must be completely replaced.

Question 28. A file that contains operating and maintenance instructions for school building equipment is extremely helpful, if not absolutely necessary, to the head maintenance engineer if he is to perform his duties properly. According to this survey, 52 percent of the schools have such a file, 32 percent do not, and 16 percent did not reply to the question. Of those schools that do not keep such a file, 48 percent say that maintenance instructions are kept in the school principal's or district superintendent's offices.

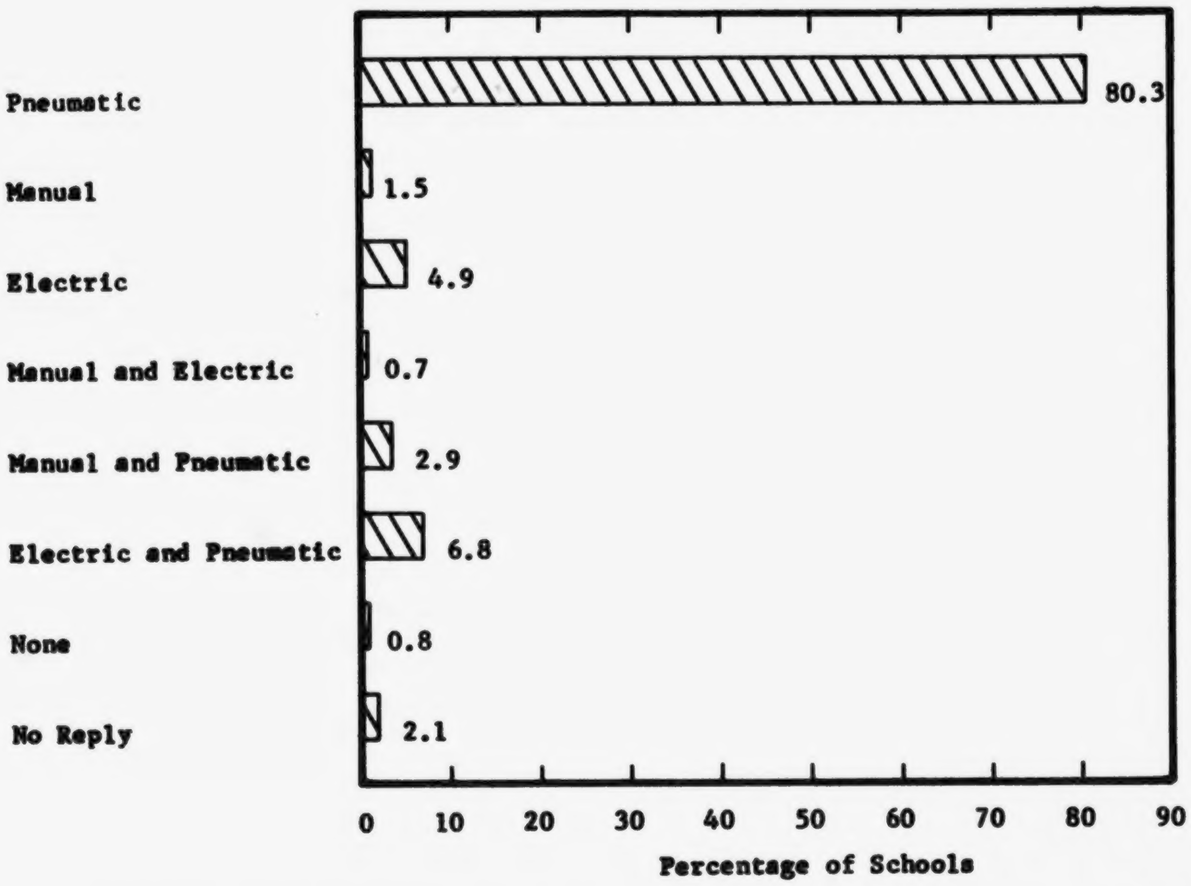

FIGURE 8. TYPES OF TEMPERATURE CONTROL SYSTEMS USED IN SCHOOL BUILDINGS

Question 29. Good maintenance procedures and practices also require that complete records be kept for each piece of OME. Only 38 percent of the school buildings keep such records, 54 percent do not, and 8 percent did not answer the question. Of those that keep such records, 7 percent send copies to the school principal, 42 percent send them to the district maintenance supervisor, 19 percent to the district superintendent, and 32 percent indicated that copies are sent to "other".

Question 30. Thirty percent of the schools are provided with a master maintenance schedule, 64 percent are not, and 6 percent did not answer. This would indicate that, at best, a preventive maintenance program is being pursued in only 30 percent of the school buildings in Minnesota.

Question 31. A master list, or location chart, that shows the location of each piece of OME can be most helpful in quickly detecting and correcting faulty equipment. Thirty-eight percent of the schools indicated that a master list was in existence, 60 percent said no, and 2 percent did not reply.

Question 32. The respondents were asked, for each item listed in Question 32, to indicate the type of maintenance performed, preventive or breakdown. In addition, they were asked to indicate whether or not the maintenance was performed by an outside contractor. A summary of the replies is given in Figure 9. The number given in parentheses after each item indicates the percentage of school buildings that checked preventive or breakdown for this item. Of these schools that checked preventive or breakdown, the first bar indicates the percentage that checked "preventive" and the second bar indicates those that checked "breakdown". The third bar gives the percentage of all schools returning the questionnaire that indicated that the work was performed by an outside contractor.

In all but a few cases, the majority indicate that preventive maintenance is performed on the item. It should also be noted that an outside contractor performs the maintenance to a large extent on the more complex types of equipment (gas burning equipment, oil burning equipment, refrigerators, dishwashing machines, pneumatic control systems, boiler controls, clock systems, fire alarm systems, etc.).

An attempt was made to establish correlations between the answers to Question 32 and other related questions, in particular Questions 28, 29, and 30, all of which are concerned with a preventive maintenance program.

On the average, of those individuals that checked preventive in Question 32, 60 percent keep an up-to-date file of instructions on maintenance procedures and 28 percent do not, 42 percent keep maintenance records and 51 percent do not, and 35 percent are provided with maintenance schedules and 60 percent are not. Thus, of those that say they are following preventive maintenance practices, 28 percent are doing so without complete maintenance information in a school building file, 51 percent are not keeping maintenance records, and 60 percent do not have a master maintenance schedule to guide their program.

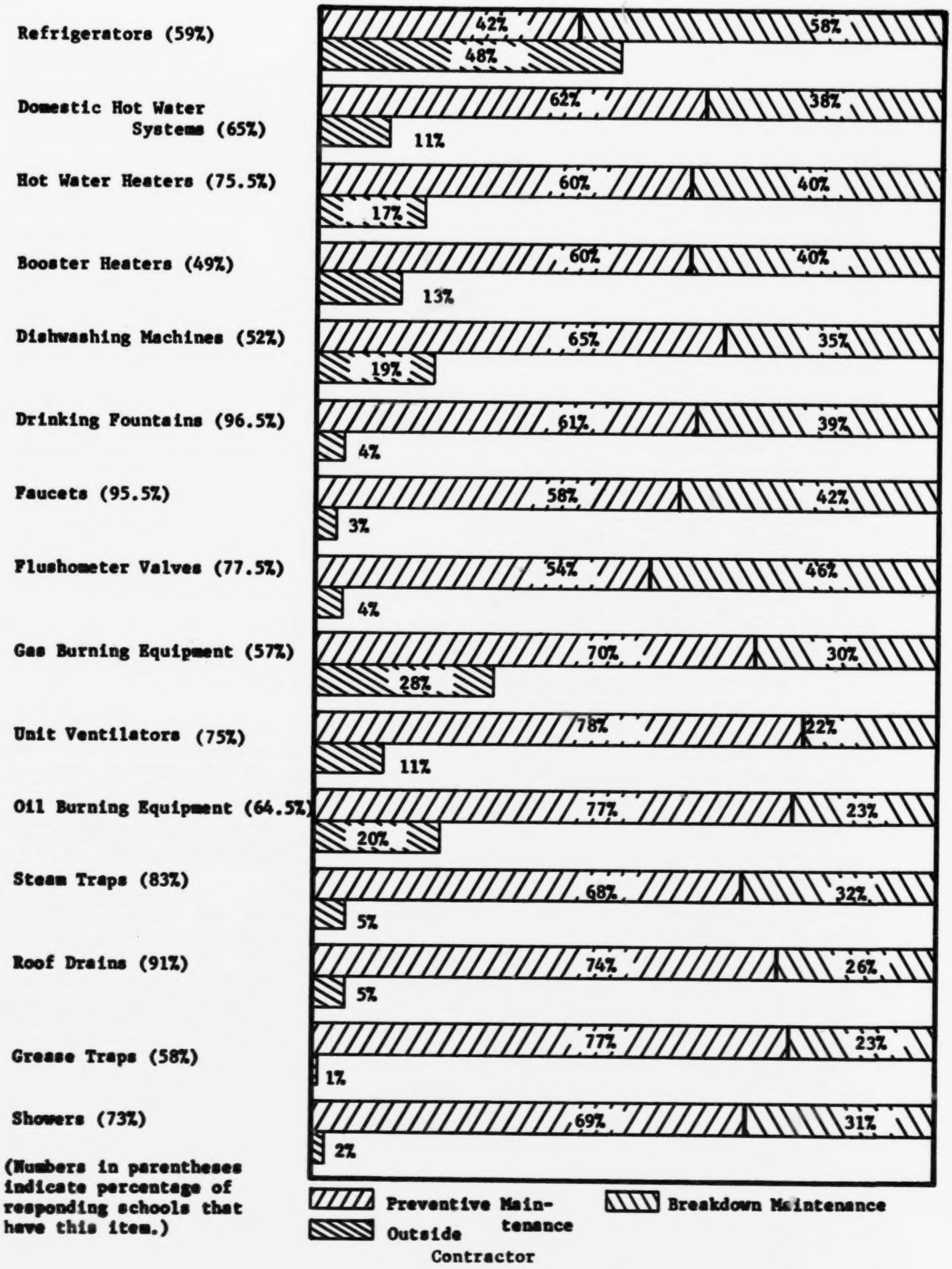

FIGURE 9. TYPES OF MAINTENANCE PERFORMED ON OPERATING MECHANICAL EQUIPMENT COMMONLY FOUND IN SCHOOL BUILDINGS

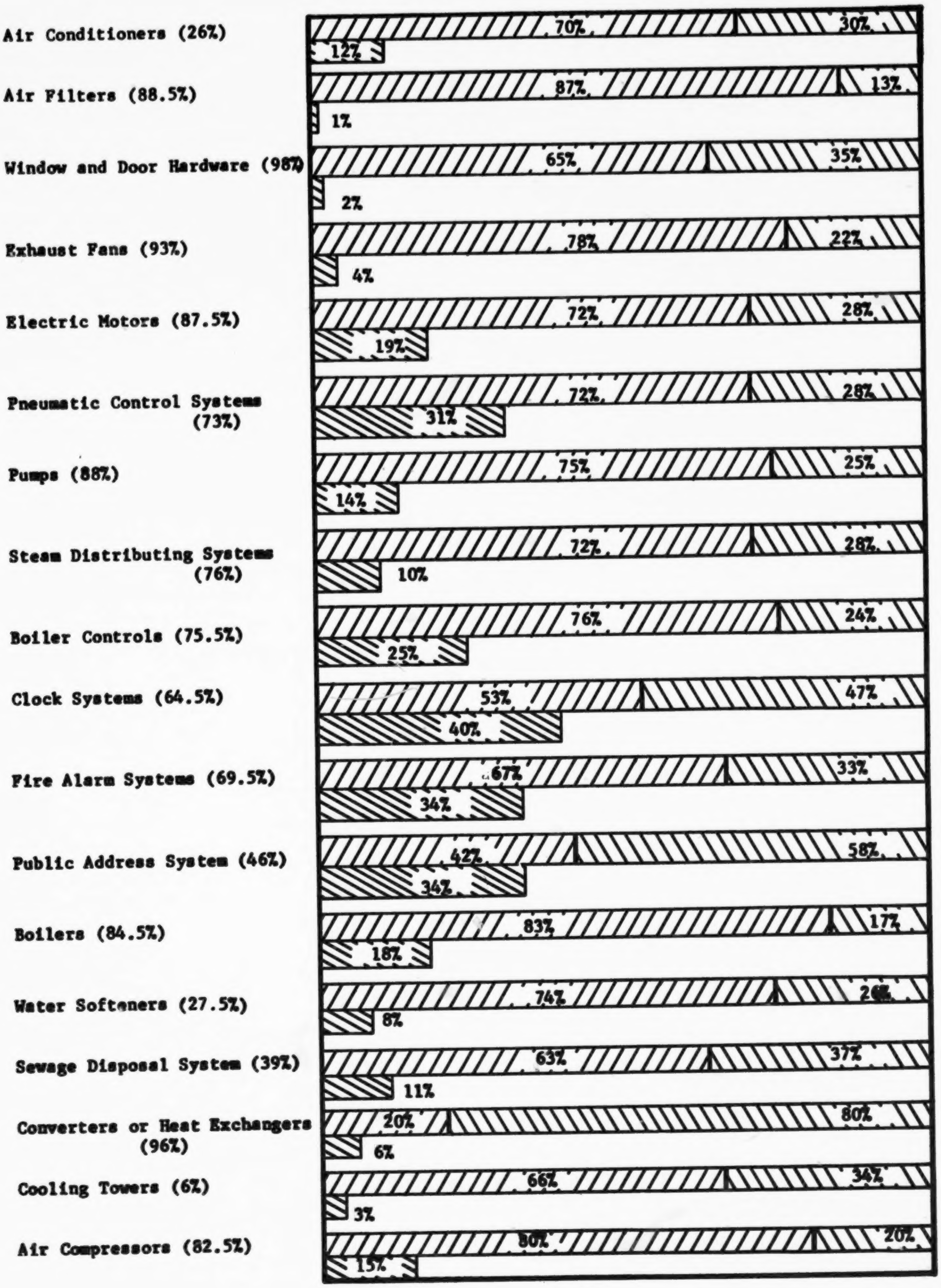

FIGURE 9 (continued).

It would appear, therefore, that no more than 35 percent (and possibly considerably less) of those claiming to have a preventive maintenance program are properly set up to carry it out effectively.

Of those indicating breakdown on Question 32, 50 percent keep an up-to-date file of instructions on maintenance procedures and 38 percent do not, 37 percent keep maintenance records and 56 percent do not, and 26 percent are provided with a master maintenance schedule and 71 percent are not. Thus, a reasonable percentage (26-50) of those with a breakdown program have some of the rudiments of a preventive maintenance program in existence.

Question 33. Very few school buildings reported equipment that is not working because it is out of repair. Of those replying, eight exhaust fans, seven unit ventilators, three drinking fountains, three water control valves, three air compressors, and two water pump systems were not operational. Additional equipment, such as a boiler, public address system, oil burner, draft fan, gym heating unit, hot water heater, water softener, vacuum pumps, and temperature controls, were reported inoperative.

Question 34. Many types of equipment that give problems were listed in the questionnaire. Table 2 summarizes the most frequently mentioned items. In general, the heating system seems to provide a major portion of the problems.

TABLE 2

OPERATING MECHANICAL EQUIPMENT THAT CAUSES THE MOST PROBLEMS FOR SCHOOL MAINTENANCE STAFFS

| Item | Number of School Buildings Involved | Item | Number of School Buildings Involved |
|---|---|---|---|
| Unit Ventilators | 82 | Hot Water Pumps | 14 |
| Clock and Bell System | 79 | Refrigerators | 14 |
| Boiler Burners | 75 | Pumps | 13 |
| Boilers | 57 | Door Checks or Locks | 12 |
| Pneumatic Controls | 55 | Drinking Fountains | 11 |
| Heating Controls | 45 | Toilets | 11 |
| Steam Traps | 42 | Furnaces | 9 |
| Boiler Controls | 38 | Sewer or Septic Tank System | 9 |
| Heating Units | 36 | Air Conditioning | 9 |
| Dishwashers | 25 | Hot Water Heater | 8 |
| Thermostats | 24 | Water Faucets and Valves | 8 |
| Condensate Pumps | 21 | Exhaust Fans | 7 |
| Flush Bowls | 21 | Water Softeners | 7 |
| Electric Motors | 17 | Flush Valves | 6 |
| Vacuum Pumps | 17 | Steam Radiators | 6 |
| Swimming Pools | 17 | P. A. Systems | 5 |
| Ventilators | 16 | Fire Alarm Systems | 5 |
| Stokers | 16 | Air Compressors | 4 |
| Washers and dryers | 16 | | |

Question 35. Only 7 percent of those returning this questionnaire keep records of the time spent on maintenance, 90 percent do not, and 3 percent did not reply. It is of interest to note that 61 percent of those who keep these records also keep records of the maintenance performed on OME (Question 29). By means of comparison, of those who do not keep records of time spent on maintenance, 36 percent keep records of the maintenance performed on equipment.

Questions 36 and 37. The average number of hours per week spent on the maintenance of OME was calculated to be 16.7. The average number of hours thought necessary was 19.9. Thus, the men in charge of maintenance believe that more time should be spent on maintenance than is allowed by current schedules. It should be noted that the number of hours required for maintenance depends upon the complexity of the building system.

Questions 38 and 39. Eighty-two percent of the respondents indicated that additional advanced training would help in the performance of their own job, 13 percent said no, and 5 percent did not answer. Seventy-nine percent believed additional advanced training would help their staff in performing their job, 11 percent said no, and 10 percent did not reply.

Question 40. Fifty-eight percent of the respondents prefer holding training programs during the school year, 35 percent prefer the summer vacation period, and 7 percent showed no preference. Of those that preferred the school year, 46.5 percent preferred the school day, 50 percent preferred a weekday evening, and 3.5 percent preferred weekends.

Question 41. Of those responding to Questions 41a, 43 percent said they would definitely attend a training course if it were held during working hours, 31 percent said probably, 15.5 percent indicated probably not, and 10.5 percent said definitely not. Of those responding to Question 41b, 35 percent said they would definitely attend a training course if it were offered during off-duty hours, 42 percent indicated probably, 15 percent said probably not, and 8 percent said definitely not. Analyzing the data further, 58.1 percent said they would attend (either definitely or probably) and 8.1 percent said they would not attend, irrespective of the course being held during working hours or "off duty" hours. Eighteen percent would attend during "off duty" hours, but not during working hours, and 15.8 percent would attend during working hours but not during "off duty" hours. Thus, the time at which the course was held would have no appreciable effect on attendance.

Question 42. There were many types of equipment for which advanced instruction was desired. A tabulation of the most frequently listed items is given in Table 3. Once again, it should be noted that a large portion of the items fall into the heating system category.

TABLE 3

TYPES OF OPERATING MECHANICAL EQUIPMENT FOR WHICH MAINTENANCE PERSONNEL DESIRE ADVANCED INSTRUCTION

| Item | Number of Individuals Desiring Advanced Instruction | Item | Number of Individuals Desiring Advanced Instruction |
|---|---|---|---|
| Pneumatic Controls | 303 | Bell System | 38 |
| Unit Ventilators | 188 | Electrical | 33 |
| Boilers | 168 | General Maintenance | 30 |
| Oil Burning Equipment | 160 | Thermostats | 30 |
| Boiler Controls | 152 | Window and Door Hardware | 25 |
| Gas Burning Equipment | 131 | All Electrical Equipment | 20 |
| Air Conditioners | 114 | Vacuum Pumps | 18 |
| Clock System | 108 | Fire Alarm | 18 |
| Refrigeration | 107 | Public Address System | 15 |
| Electric Motors | 87 | Dishwashers | 14 |
| All Heating Systems | 69 | Plumbing | 13 |
| Pumps | 59 | Hot Water Heaters | 10 |
| Steam Traps | 57 | Water Softeners | 10 |
| All Mechanical Equipment | 45 | Air Compressors | 10 |
| Steam Distributing System | 41 | | |

Question 43. A considerable variety of comments and suggestions was given in this question. In general, the comments were mainly concerned with training, working conditions, record keeping, and wages. Typical responses are given below.

Many comments on maintenance training were received. For example, one respondent said, "I think everyone going into school maintenance work should have some kind of training before they start, or near the starting time of their job". Another custodian commented, "Being the only janitor in this school, I find it hard to keep up with many of the new things. I could use more time for study. It seems I always find things I should know about. I would like to be able to go to a good institute or workshop for about two days about three times a year".

With respect to new installations, one respondent noted that, "Architects and heating engineers are not holding enough conferences for proper maintenance and preventive care of equipment. They should supervise more closely during the year following the installation for proper operation. Each type of equipment operates differently under local conditions and buildings".

With respect to an annual training course, one individual stated, "I believe that an annual training and refresher course would be of great value to the employees, as well as to the school system. This would help us keep up-to-date on methods, etc.", and another said, "New models and methods are being introduced each year. Therefore, the maintenance man must learn more about machines and materials to properly do his work. Therefore, I think attendance at these courses should be a 'must' for such people". One respondent offered the statement, "The more technical training we get benefits the schools in two ways. We can do more ourselves and we are better teachers for new men just starting the system". Another said, "An instruction course is a 'must' because of the mechanical changes that are taking place in the public school today", and still another stated that, "We definitely need a course for new men".

Many maintenance men believed that a good training course would benefit the school system. For example, one individual stated, "What little I have learned was picked up from experience through the years. But with today's modern schools and buildings, I think a trained man with general overall knowledge in the field is a much better asset to the schools", and another said, "I sincerely hope you can come up with a training program of some sort. I think custodial help should be and is long overdue to be upgraded. Any basic training in electrical work should be of great benefit to all schools and workers".

Another respondent said, "I believe a course that would cover the general maintenance of schools would be helpful. A preventive maintenance course given by a reputable teacher and not some sales organization. Every repairman will tell you to grease motors differently".

One of the maintenance men felt that "State employees should call on us and offer maintenance suggestions, etc.". Another individual felt that proper maintenance was absolutely necessary and stated, "In my opinion, the need for additional training is a much-needed condition. Is it right for the taxpayer to pay for a million-dollar building and then hire untrained men to maintain it? As a custodian, I would like to take pride in my work and the building I work in. I think I need more training. Thank you for your interest".

Another person commented that, "I was put on this job without any training at all, and I sure know how helpful a little training or experience would have been. You just can't learn too much".

One respondent suggested that, "Short courses should be given every five years or so to keep up with advancements, etc.".

One individual believed that training should go beyond mechanical equipment and said, "Custodians should be taught how important their job is with regard to safety, getting along with people, understanding their leaders and giving them respect, and how important it is to be neat and clean at all times. How to be alert at all times and not to depend on someone else for every job that comes up. How important it is to keep janitor equipment in its place. These are some of the things they should learn. They should be given a test to see if they are the type of men to work in our schools".

Still another person stated, "I have attended several sessions of training schools, so I am not interested until we are permitted to expand on more technical training where the custodial staff can do more of the mechanical training themselves. Our buildings are in dire need of capable men on the job right now, ready and able to keep our plants running and operating, plus keeping the many small pieces of equipment in audio-visual and science operating. Ninety percent of this equipment would not have to be taken out of service for several days and be sent away for repairs. These items alone could save many taxpayers' dollars".

These comments show that many of the maintenance supervisors are cognizant of the importance of proper maintenance procedures and the necessity of maintaining and improving their proficiency by continuous study. They are to be commended for this attitude.

Many comments about working conditions were received, for example, "A large part of the school building is over 75 years old. The heating plant and ventilating controls are so ancient, no one would believe in this modern day that we can operate at all. In the fall of 1968, the new school will be opened and it will have modern operating mechanical equipment. At that time, there will be a need for mechanical knowledge of the equipment and a maintenance log kept on the same".

Another person felt that, "The biggest problem is the fact that our school has been built at three times in fifty years. And to find parts to fix and maintain some things, as flush valves and other older devices in the building".

A lack of adequate storage space was mentioned by many respondents, for example, "We need more storage space for paper, lawn mowers, snow equipment, storm windows, and other things".

Inadequate storage space was evident even in new buildings as evidenced by the following statements: "When they build new schools, I wish the architects would give the janitors a supply room for supplies and maintenance -- we have nothing", and, "I think that more consideration should be given to storage areas in new building construction".

Another person believed that designers and builders should "allow room for a man to be able to take care of and maintain equipment you put in the school. Have charts that go with mechanical equipment that will last for years, not books that get thrown away in superintendents' offices". One person indicated that he should have "less hours than the 50-65 hours put in when school is in session", and another said he needed "more time for mechanical maintenance".

One custodian described his school system as follows: "As head custodian, I think too much of my time is taken up on routine cleaning, preventing proper maintenance of mechanical equipment. In this district, most everything is maintained on a breakdown basis, and there is a very poor inventory of parts and tools. We badly need a system to train personnel".

Another man thought that, "In some way, someone should separate the maintenance men from the janitor duties. Somebody wrote a book telling how many square feet of space on man can handle. Then a superintendent gets hold of it and figures out we have too much help and lets one go, not considering this to be three different floors and working conditions are not the best. Too many teachers think janitorial duties are one of the lowest types and we are not allowed to earn a fair wage. Why does the school system do away with overtime? They say we are not entitled to it as we are 'public servants'. As of now, we put in from 10-11 hours a day, and when night things start, it will be 15-16 hours per day. So you tell me, when do we have time to take the training?"

Only a few respondents indicated that they were satisfied with working conditions. For example, "Personally, I have enjoyed all of my years with the Board of Education. My hours are good, superintendents and cooperation from the main office are excellent", and, "I like it here. I have had good equipment to work with and I have tried to keep it in A-1 condition".

One individual said, "It is my suggestion that the operation of mechanical equipment be full-time or a major portion thereof". Another man posed the question, "Why aren't new schools equipped with better facilities for janitors?"

With respect to proper record-keeping, one man said, "We need more logs of maintenance work done and schedules of work to be done", and another indicated that he "could use record sheets to keep data on maintenance and scheduled maintenance".

One person said that, "I believe a log or file on heating fuel consumption could be very helpful". With regard to wages, one individual stated that, "Salaries should be high enough to attract capable people", and another said, "Good pay to attract good personnel". One respondent commented, "With all of the responsibility involved, it is pretty hard to swallow the old cliche that you are only a janitor when raise-time comes around". Another offered the suggestion, "I would like to see a salary schedule based on seniority, experience, talent, and knowledge. A scale somewhat similar to what teachers have".

The response of one individual was quite lengthy, but it appears to summarize the general beliefs of many of the respondents. "An overcrowded situation multiplies the frequency of cleaning and repair, so more attention should be given to the fact that square footage alone is not the deciding factor on the number of custodians. A definite work schedule and system of records is becoming a 'must'. Complex equipment and machinery demands qualified and well-trained personnel. Pay and esteem are below par; it seems that a person or persons responsible for the safety of about $15 million worth of lights and property would be recognized for such. The last area training course available to us was in the 1950's.

"It is my firm belief that some training should be had before entering as a maintenance staff member. Thereafter, a one- to two-year extensive study program, with periodic training to follow, should be encountered.

"I see it as an 'any man off the streets' situation at the present time, at least as far as school buildings are concerned. The preceding thought may continue as long as hiring of personnel remains with local school boards, or we remain without group representation such as a union or guild.

"I have been head custodian of this school for 10 of the 16 years employed. During this time, no demand was made for records of daily maintenance. The only records asked for were 'tool and equipment inventory', and 'work schedule' for each. The work schedules are flexible and overlapping so we can help each other when the need exists. During the summer vacation and at Christmas, we work together on repairs and cleaning operations. The lack of records presents a problem now of establishing proof for need of additional help. We are taking care of what three men should. This, in turn, results in a longer day (10-14 hours) for each man with no overtime consideration.

"It pleases me that we do have a good file system of installation, care, and maintenance of the major equipment. I collected this by being on the spot when installation was made, or by writing to the manufacturer for same.

"Another thing in favor of present-day custodians is the gradual breakdown of school boards operating on 'tight' budgets. There was a time -- not too long ago -- when a piece of equipment had to be repaired many times rather than replaced. This reasoning led to a general or area breakdown whereby a major improvement was necessary. Participation in state aids to the allowable extent, along with other foundation aids, released enough money to make the capital improvements which were long overdue. Another ten years of 'shoestring budgets' would have reduced our building to shambles, kept down enrollment, and probably caused the district to be swallowed by a larger one, as is the case with some.

"There should also be periodic training for people who make use of a public building. Instruction should be given in the areas of wiping shoes upon entering, proper use of lavatory facilities, awareness of the expense incurred in providing lawns, shrubbery and recreational equipment. The above seems also to be an untapped field of study."

School Building General Information Questionnaire

This questionnaire was designed to obtain information about the physical characteristics of each school building (Figure 10) and was to be completed by the office staff in each building. Data on the classification, enrollment, age, types and extent of additions, and size of the buildings were requested. Questions soliciting information on the types, extent, and seriousness of failures in mechanical equipment; annual heating costs; and maintenance staff data are included.

Question 1. In this question, which pertains to the school classifications, only 20 did not provide the requested information. The number of school buildings falling into each classification is given in Table 4.

TABLE 4

CLASSIFICATIONS OF SCHOOL BUILDINGS RETURNING THE SCHOOL BUILDING GENERAL MAINTENANCE QUESTIONNAIRE

| Classification of School Building | Number of Buildings | Classification of School Building | Number of Buildings |
|---|---|---|---|
| Elementary | 629 | Vocational Secondary | 1 |
| Four-Year Secondary | 14 | Elementary and Four-Year Secondary Combined | 14 |
| Six-Year Secondary | 143 | Elementary and Six-Year Secondary Combined | 145 |
| Junior Secondary | 72 | Elementary and Junior Secondary Combined | 11 |
| Senior Secondary | 63 | Elementary and Senior Secondary Combined | 3 |
| Area Vocational-Technical | 14 | Eight-Year Secondary | 1 |

Question 2. Of the 1,130 buildings for which this questionnaire was returned, student enrollment data was provided for 1,054 schools. The average enrollment for these buildings was 579 students per building. Assuming that this average is also valid for the 76 buildings that did not reply to the question, it is estimated that the total enrollment for all school buildings returning this questionnaire amounts to 655,000. The Minnesota Education Directory, 1966-1967, gives the total state enrollment as 832,962. Therefore, this questionnaire was returned by schools representing approximately 78.6 percent of the students in the state.

Question 3. It was believed that information about the original year of construction of the school building could provide insight into the maintenance conditions of OME. The original year of construction of the school building was provided by 1,069 respondents. The data indicate that the average age of school buildings in Minnesota is 27 years.

Question 4. Information about the original floor area is necessary in comparing school buildings. The data provided by the respondents indicate that the average Minnesota school building had an original floor area of 40,800 square feet, and that 63 percent of the school buildings in Minnesota have a basement.

Question 5. The number of floors in the school buildings as originally constructed (counting the basement as a floor) provides information that may be useful for detailed comparisons of different school buildings. The information provided by the respondents indicate that, on the average, Minnesota school buildings have 2.39 floors.

Question 6. The information about major additions to the school building (year, floor area, number of floors) was varied and will not be presented in this report. However, it is available for analysis should the need ever arise.

Question 7. The average present floor area, including basements, was reported to be 63,200 square feet. This indicates that, on the average, additions to the original school buildings represent approximately 35 percent of the total present floor area.

Question 8. Only 6.2 percent of the schools reported breakdowns or failures of operating mechanical equipment within the last five years that interfered with the educational functions of the school, 90.3 percent said there was none, and 3.5 percent did not answer. For each category of school in Question 1, the percentage of schools that were closed because of breakdowns was about the same. Thus, no noticeable trend between breakdowns and type of school was noted. The schools indicating breakdowns were, on the average, 4.5 years older than those indicating no failures, thus showing a slight trend of increased number of breakdowns with age of the building.

## MINNESOTA SCHOOL SURVEY

## MAINTENANCE OF OPERATING MECHANICAL EQUIPMENT
## IN MINNESOTA SCHOOL BUILDINGS

### SCHOOL BUILDING GENERAL INFORMATION QUESTIONNAIRE

(To be completed for each school building in the district by the local district office staff)

School Building Name ____________ Telephone Number ________

Address ____________

Local School District Number ________

Principal's Name ____________

---

1. Please indicate the classification of this school.

   ☐ Elementary
   ☐ Four-year Secondary
   ☐ Six-year Secondary
   ☐ Junior Secondary
   ☐ Senior Secondary
   ☐ Area Vocational-Technical
   ☐ Vocational Secondary

2. Please give the total student enrollment in this building last year. ________

3. In what year was this building or the first unit of this building constructed? ________

4. What was the original floor area, excluding later additions, of this school? (Include basement floor area) ______Square feet

   ☐ Check here if building has a basement.

5. How many floors, counting the basement as a floor, were in this school when it was originally constructed? ________

6. Please give the information requested below for each major addition made to this school.

| Year Major Addition was Completed | Total Floor Area, Including Basement, of the Addition (Square feet) | Check Here if the Addition has a Basement | Total Number of Floors, Including Basement, in the Addition |
|---|---|---|---|
| ______ | ______ | ☐ | ______ |
| ______ | ______ | ☐ | ______ |
| ______ | ______ | ☐ | ______ |
| ______ | ______ | ☐ | ______ |

(OVER)

-2-

7. What is the present total floor area, including basements, of this building? ______Square feet

8. Have there been any breakdowns or failures of operating mechanical equipment (see definition at bottom of this page) within the last five years that interfered with the educational function of this school?

   ☐ Yes ☐ No

   If "No", skip to question 9.
   If "Yes", please provide the requested information for each breakdown on the next page.

9. For each item listed below, please indicate the total amount used by this school last year and the total cost of each.

   Gallons of fuel oil ________ Total cost of fuel oil ________
   Cubic feet of gas ________ Total cost of gas ________
   Tons of coal ________ Total cost of coal ________
   Quantity of other fuel ________ Total cost of other fuel ________

10. Does this school have a fire alarm system directly connected to fire stations or another area that is manned 24 hours per day? ☐ Yes ☐ No

11. Does this school building have a coded fire alarm system (one that indicates the location of initiation of alarm)? ☐ Yes ☐ No

12. Does the person in charge of the operating mechanical equipment in this building have any operating mechanical equipment maintenance assistants?

    ☐ Yes ☐ No

    If "No", skip to question 13.
    If "Yes", answer 12a and 12b.

    12a. How many operating mechanical equipment maintenance assistants does he have? ______
    12b. Does this person also supervise the custodial staff?

    ☐ Yes ☐ No

13. Do the senior operating mechanical equipment maintenance personnel in this school provide scheduled on-the-job training to junior personnel?

    ☐ Yes
    ☐ No
    ☐ Not applicable, only one maintenance man or one custodian for this school

14. How many man-hours per week do you think are necessary to maintain operating mechanical equipment in this school building adequately?

    Man-hours per week ________

---

Definition: Operating Mechanical Equipment -
Equipment having moving parts that are actuated by a power source; for instance, unit ventilators, heating and ventilating control systems, clock and bell systems, elevators, refrigeration systems, electric motors, automatic dishwashers, garbage disposers, etc.

FIGURE 10. SCHOOL BUILDING GENERAL INFORMATION QUESTIONNAIRE

|  |  |  | Component was |  | By whom was the component repaired or replaced? |  |  | If any classes had to be dismissed because of this breakdown, please give the following information. |  |  |
|---|---|---|---|---|---|---|---|---|---|---|
| Date of Breakdown | Type of Equipment Involved | Part or Machine that Failed | Repaired | Replaced | School Employee | Other | Cost* | Number of Classrooms Dismissed | Check here if this number of classrooms represents the entire school | How many days were classes dismissed because of this breakdown? |
|  |  |  | ☐ | ☐ | ☐ | ☐ |  |  | ☐ |  |
|  |  |  | ☐ | ☐ | ☐ | ☐ |  |  | ☐ |  |
|  |  |  | ☐ | ☐ | ☐ | ☐ |  |  | ☐ |  |
|  |  |  | ☐ | ☐ | ☐ | ☐ |  |  | ☐ |  |
|  |  |  | ☐ | ☐ | ☐ | ☐ |  |  | ☐ |  |
|  |  |  | ☐ | ☐ | ☐ | ☐ |  |  | ☐ |  |
|  |  |  | ☐ | ☐ | ☐ | ☐ |  |  | ☐ |  |
|  |  |  | ☐ | ☐ | ☐ | ☐ |  |  | ☐ |  |
|  |  |  | ☐ | ☐ | ☐ | ☐ |  |  | ☐ |  |
|  |  |  | ☐ | ☐ | ☐ | ☐ |  |  | ☐ |  |

* Cost should include material and, if repaired or replaced by someone not employed in the school system, it should include his wages.

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FIGURE 10. (CONTINUED)

From the responses, no one piece of equipment appeared to break down more frequently than another. Equipment mentioned by the respondents is listed in Table 5.

TABLE 5

OPERATING MECHANICAL EQUIPMENT THAT HAS BROKEN DOWN WITHIN THE LAST FIVE YEARS

| Equipment | Number of Cases Reported | Equipment | Number of Cases Reported |
|---|---|---|---|
| Motors | 17 | Boiler Feedwater System | 2 |
| Pumps | 12 | Pressure Regulator | 1 |
| Burners | 6 | Electrical Control Panel | 1 |
| Stokers | 4 | Compressors | 1 |
| Thermostats | 4 | Garbage Disposer | 1 |
| Fans | 3 | Oil Pump Heater | 1 |
| Furnace or Boiler | 3 | Boiler Water Regulator | 1 |
| Dishwashers | 2 | Boiler Flues | 1 |
| Clocks and Bells | 2 | | |

Question 9. The amount and cost of each type of fuel was not provided by many schools. The information given in the district questionnaire was more complete and has proven more useful for the study.

Question 10. Nine percent of the buildings have a fire alarm system directly connected to fire stations, 88 percent do not, and 3 percent did not answer. The student enrollment in schools with such a system also represents approximately nine percent of the total state enrollment.

Question 11. All school buildings are required to have fire alarm systems. In larger and more complex buildings, coded systems are required. Of all schools that responded, 14.2 percent have a coded fire alarm system, 83.3 percent do not, and 2.5 percent did not answer. Twenty-one percent of the students in the state are in buildings with a coded fire alarm system. The school buildings with this system, on the average, are about four years newer and 70 percent larger than schools without the system.

Question 12. The person in charge of the OME has maintenance assistants in 44.2 percent of the schools, and does not in 51.7 percent; 4.1 percent did not answer the question. On the average, school buildings in which the head maintenance man has assistants are 60 percent larger than those where he does not. An average of 1.6 assistants was reported for those buildings with more than one custodian or maintenance man. Of the schools that have maintenance assistants, the head maintenance man also supervises the custodial staff in 71 percent of the buildings.

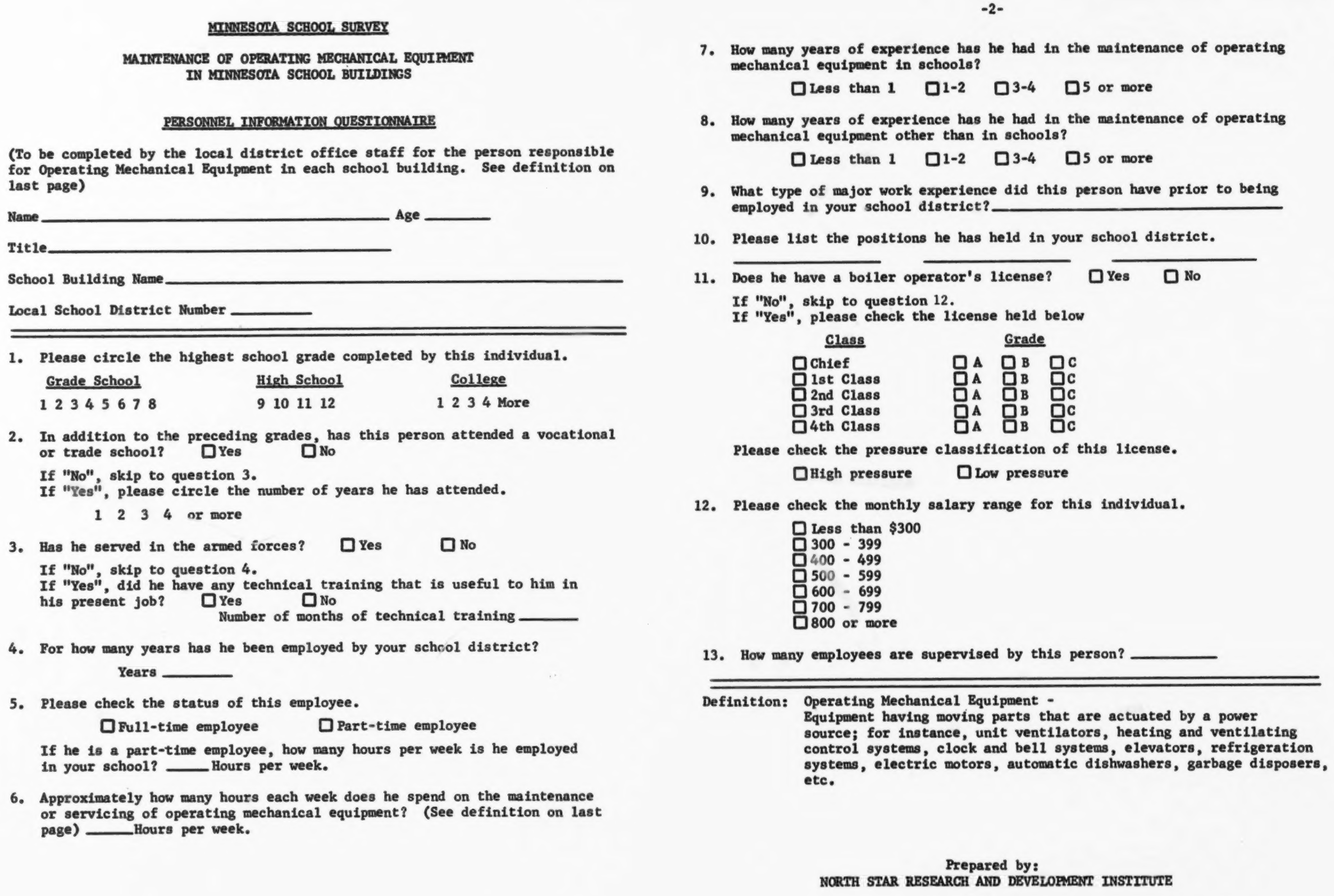
Question 13. In buildings with both senior and junior personnel, the senior personnel provide scheduled on-the-job training to the junior personnel in 37 percent of the schools and do not in 63 percent.

Question 14. The local school administrator responding believed that on the average, 15.7 hours per week was a sufficient amount of time to maintain equipment in the school building. It is interesting to compare this estimate with the 19.9 hours per week thought necessary by the head custodian.

## Personnel Information Questionnaire

This questionnaire (see Figure 11), to be completed by the district office staff, provided background information about the head maintenance man for each school building in the district. Included are questions pertaining to the amount of formal education obtained by the individual and his employment experience and background. It was hoped that such information would provide significant correlations between the level of maintenance performed and the various qualifications of the head custodian or maintenance engineer. The average age of the head maintenance man in all the schools surveyed is 50.3 years.

Question 1. This question, pertaining to formal education of head custodians, was answered in 97.3 percent of the 1,057 questionnaires returned. The distribution of formal education of the head maintenance men is shown in Figure 12. Five percent of the men have attended college, 35.7 percent completed their formal education with a high school diploma, 20.1 percent have attended 1-3 years of high school, 33.6 percent have completed grade school, 2.9 percent have less than an eighth grade education, and 2.7 percent did not answer. The average age is 43 for those completing from 1-4 years of grade school, 53.5 for those completing 5-8 years of grade school, 47 for those finishing 9-12 years of education, and 51 for those completing 13 or more years of school.



MINNESOTA SCHOOL SURVEY

MAINTENANCE OF OPERATING MECHANICAL EQUIPMENT
IN MINNESOTA SCHOOL BUILDINGS

PERSONNEL INFORMATION QUESTIONNAIRE

(To be completed by the local district office staff for the person responsible for Operating Mechanical Equipment in each school building. See definition on last page)

Name ______________________ Age ________

Title ______________________

School Building Name ______________________

Local School District Number ________

---

1. Please circle the highest school grade completed by this individual.

| Grade School | High School | College |
|---|---|---|
| 1 2 3 4 5 6 7 8 | 9 10 11 12 | 1 2 3 4 More |

2. In addition to the preceding grades, has this person attended a vocational or trade school? ☐ Yes ☐ No

   If "No", skip to question 3.
   If "Yes", please circle the number of years he has attended.

   1 2 3 4 or more

3. Has he served in the armed forces? ☐ Yes ☐ No

   If "No", skip to question 4.
   If "Yes", did he have any technical training that is useful to him in his present job? ☐ Yes ☐ No
   Number of months of technical training ________

4. For how many years has he been employed by your school district?

   Years ________

5. Please check the status of this employee.

   ☐ Full-time employee ☐ Part-time employee

   If he is a part-time employee, how many hours per week is he employed in your school? _____ Hours per week.

6. Approximately how many hours each week does he spend on the maintenance or servicing of operating mechanical equipment? (See definition on last page) _____ Hours per week.

-2-

7. How many years of experience has he had in the maintenance of operating mechanical equipment in schools?

   ☐ Less than 1 ☐ 1-2 ☐ 3-4 ☐ 5 or more

8. How many years of experience has he had in the maintenance of operating mechanical equipment other than in schools?

   ☐ Less than 1 ☐ 1-2 ☐ 3-4 ☐ 5 or more

9. What type of major work experience did this person have prior to being employed in your school district? ______________________

10. Please list the positions he has held in your school district.

    ____________ ____________ ____________

11. Does he have a boiler operator's license? ☐ Yes ☐ No

    If "No", skip to question 12.
    If "Yes", please check the license held below

| Class | Grade | | |
|---|---|---|---|
| ☐ Chief | ☐ A | ☐ B | ☐ C |
| ☐ 1st Class | ☐ A | ☐ B | ☐ C |
| ☐ 2nd Class | ☐ A | ☐ B | ☐ C |
| ☐ 3rd Class | ☐ A | ☐ B | ☐ C |
| ☐ 4th Class | ☐ A | ☐ B | ☐ C |

    Please check the pressure classification of this license.

    ☐ High pressure ☐ Low pressure

12. Please check the monthly salary range for this individual.

    ☐ Less than $300
    ☐ 300 - 399
    ☐ 400 - 499
    ☐ 500 - 599
    ☐ 600 - 699
    ☐ 700 - 799
    ☐ 800 or more

13. How many employees are supervised by this person? ________

---

Definition: Operating Mechanical Equipment -
Equipment having moving parts that are actuated by a power source; for instance, unit ventilators, heating and ventilating control systems, clock and bell systems, elevators, refrigeration systems, electric motors, automatic dishwashers, garbage disposers, etc.

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FIGURE 11. PERSONNEL INFORMATION QUESTIONNAIRE

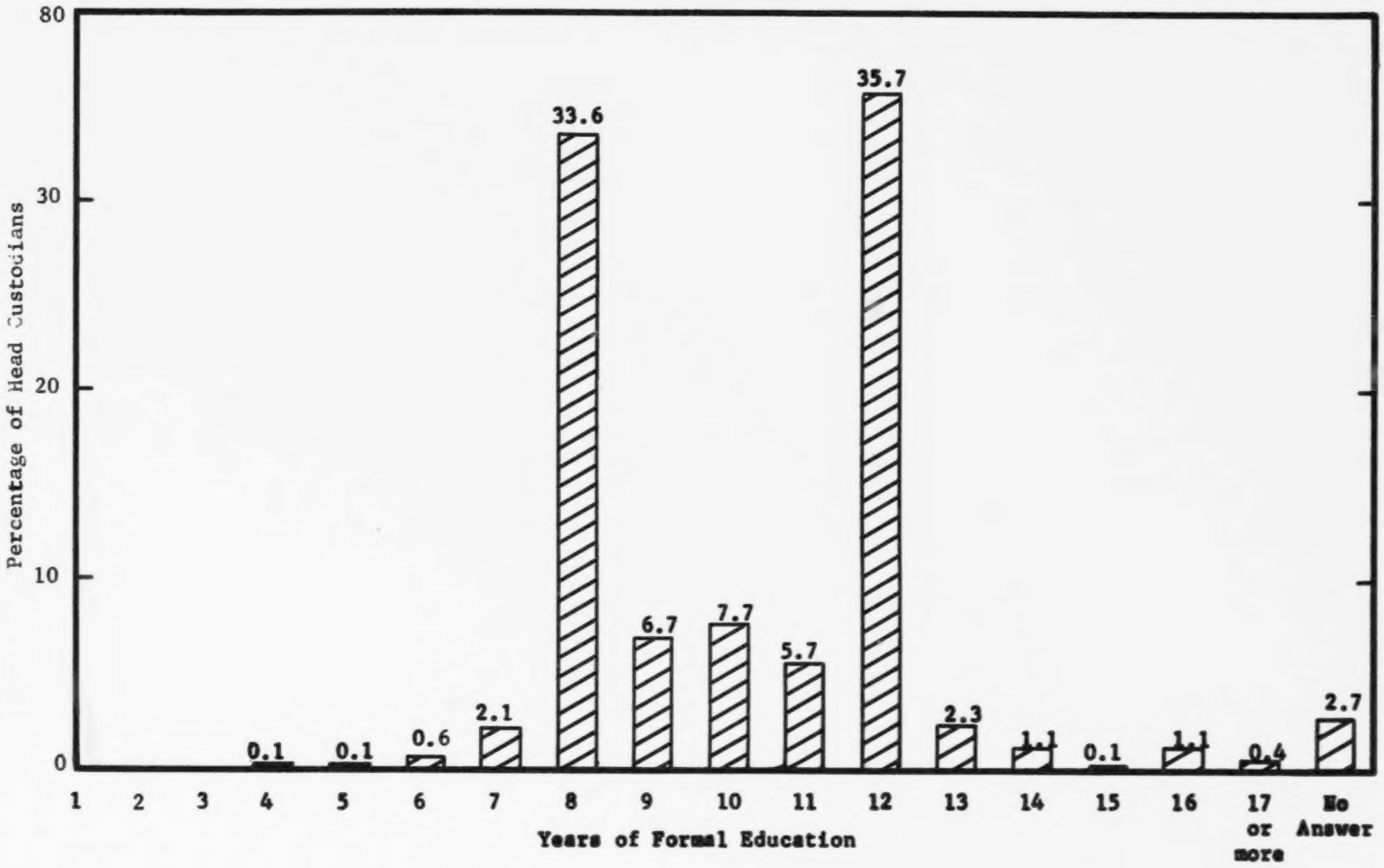

FIGURE 12. **FORMAL EDUCATION OF HEAD CUSTODIANS**

Question 2. In the returned questionnaires, 19 percent of the head maintenance men have attended a vocational or trade school, 69 percent have not, and 12 percent did not reply. Of those who attended such a school, 53 percent completed one year, 31 percent attended two years, and 16 percent completed more than two years.

Question 3. In the returned questionnaires, 40.5 percent of the head maintenance men served in the armed forces, 50 percent did not, and 9.5 percent did not reply. Of those who served, 35 percent had technical training that is useful in their present job, and 65 percent did not. The amount of technical training averaged 10.8 months for those reporting.

Question 4. An average of 12.1 years of employment of the head maintenance men by the school district was reported by the 99 percent of the respondents answering this question.

Question 5. Only 1.5 percent of the head maintenance men were reported to be part-time employees, averaging 28 hours per week. The remaining 98.5 percent were listed as full-time employees.

Question 6. For the 1,029 questionnaires in which this question was answered, an average of 12.4 hours per week was spent by the responsible person on maintenance of operating mechanical equipment.

Question 7. The majority, 81.4 percent, reported that the head maintenance man had five or more years of experience in the maintenance of OME in school buildings. Three percent reported less than one year, 5.5 percent indicated 1-2 years, 8.9 percent said 3-4 years, and 1.2 percent did not answer the question.

Question 8. Of those returning this questionnaire, 21.1 percent reported that the head maintenance man had less than one year of experience in maintenance of OME other than in schools, 6 percent reported one to two years of experience, 6.4 percent said three to four years, 55.1 percent indicated five or more years of experience, and 11.4 percent did not answer. Data from both Questions 7 and 8 show that more than 50 percent of the head maintenance men in school buildings have had ten or more years of related maintenance experience in and out of school buildings.

Question 9. The most frequently mentioned major work experience is tabulated in Table 6. Many head custodians were farmers previous to their employment in the school. Many other types of work were mentioned, including bookkeeping, welding, painting, steam and pipe fitting, architect, radio-TV repair, teaching, roofing, metal stamping, mailman, cheese making, milkman, ship maintenance, steelmaking, draftsman, restaurant manager, telephone repairman, depot agent, logging, paper milling, blacksmith, public relations, plastering, bartender, photographer, and crane operator.

TABLE 6

PREVIOUS WORK EXPERIENCE OF HEAD CUSTODIANS

| Type of Work | Number Reporting Experience in this Type of Work | Type of Work | Number Reporting Experience in this Type of Work |
|---|---|---|---|
| Farmer | 191 | Sales | 38 |
| Machinist or Machine Shop Experience | 68 | Plumbing | 29 |
| Mechanic | 66 | Electrician | 29 |
| Truck Driver | 61 | Mechanical | 26 |
| Carpenter | 55 | Boiler Work | 25 |
| Construction Work | 54 | Bus Driver | 14 |
| Maintenance Engineer | 47 | Fireman | 14 |
| Laborer - General | 43 | Helper on Railroad | 13 |
| Creamery Work | 38 | Service Station Attendant | 13 |
| Custodian | 38 | None | 10 |

Question 10. The positions that have been held in the school district by the present head custodian are presented in Table 7.

TABLE 7

POSITIONS THAT HAVE BEEN HELD IN THE SCHOOL DISTRICT BY THE HEAD CUSTODIAN

| Position | Number of People Reported to Have Held This Position |
|---|---|
| Custodian | 724 |
| Head Custodian | 312 |
| Maintenance Engineer | 176 |
| Bus Driver | 111 |
| Fireman | 32 |
| Yard Worker | 2 |
| Assistant Custodian | 17 |

Question 11. From the returned questionnaires, 24.6 percent of the head custodians have a chief class boiler operator's license, 30.3 percent have a first class license, 26.3 percent have a second class, 2.2 percent have a third class, 6.7 percent have a fourth class, and 7.2 percent do not have a boiler operator's license. 2.7 percent did not answer the question.

Of the reported boiler operator's licenses, 8.4 percent are Grade A, 6.9 percent are Grade B, 75.3 percent are Grade C, and 9.4 percent were not specified as to grade. Only 7.1 percent of the licenses are for high pressure, 90 percent are for low pressure, and 2.9 percent were not specified as to pressure classification.

Question 12. Only 2.4 percent of the respondents did not indicate the salary level of the head maintenance man. For those that did reply, the percentage falling into each salary range is shown in Figure 13.

Question 13. For those that answered this question, an average of three employees are supervised by the head custodian.

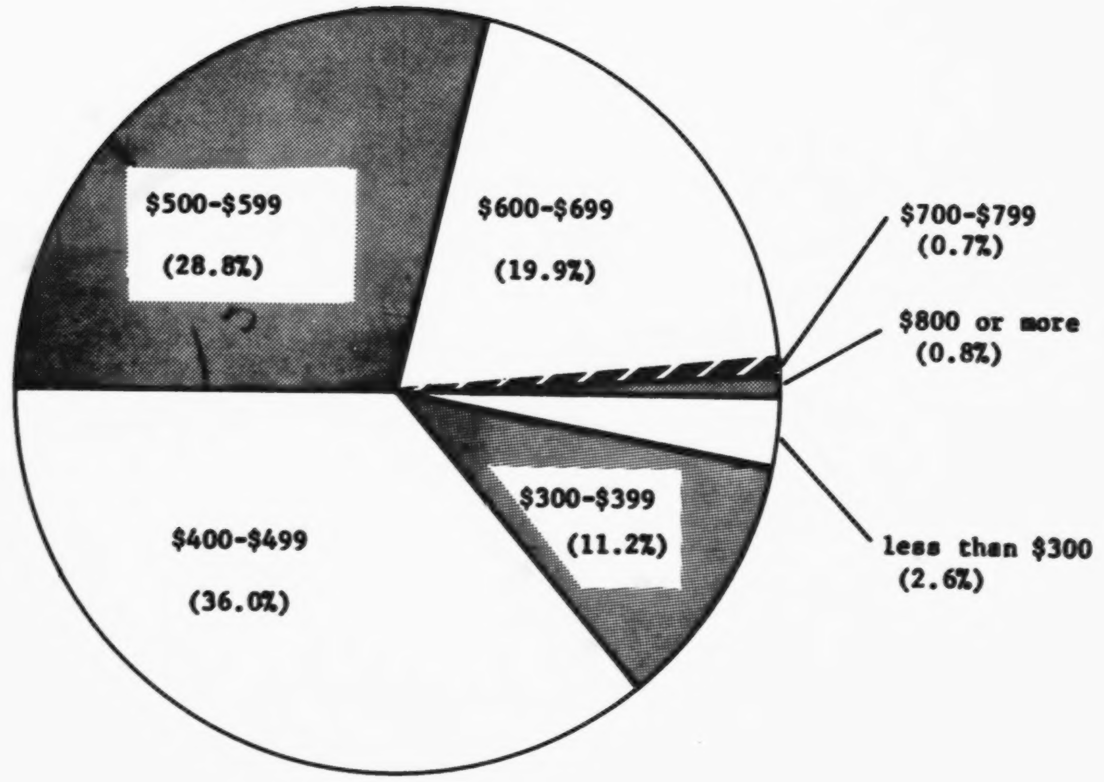

FIGURE 13. MONTHLY SALARIES OF HEAD MAINTENANCE PERSONNEL

Local School District Questionnaire

The purpose of this questionnaire was to obtain information, at the district level, about the maintenance program followed by each district. Once again, it was anticipated that significant correlations would be found between this and the other questionnaires. The questionnaire is shown in Figure 14.

Question 1. Replies to this questionnaire came from 368 districts, having a combined total of 862 elementary schools, 19 four-year secondary schools, 247 six-year secondary schools, 114 junior secondary schools, 99 senior secondary schools, 21 area vocational-technical schools, and three vocational secondary schools.

Question 2. For those districts that answered this question (357), an average enrollment of 1,725 students per district was reported. Eleven of the districts that returned this questionnaire did not answer this question. If we assume that these districts have the same average enrollment, the total student enrollment in the districts that returned this questionnaire is 635,000, representing 76.5 percent of the total net enrollment in the state as reported in the Minnesota Educational Directory, 1966-1967.

Question 3. According to the replies, 130 districts issue contracts for clock and bell system maintenance, 89 districts have contracts for heating and ventilating control systems, 56 issue office equipment maintenance contracts, and 24 districts issue other types of heating system repair contracts. A number of districts indicated other contracts concerned with items such as the public address system, refrigerators, elevators, garbage disposers, washers and dryers, etc.

Question 4. Ninety percent of the responding districts provided information about annual fuel costs. The total fuel cost for these districts was calculated to be $4,571,817. The total student enrollment in these districts amounts to 583,606, thus providing an average annual fuel cost per student of $7.83. Assuming that this average value is the same for the remaining districts in the state, it can be estimated that the annual fuel costs for all school buildings in Minnesota amounts to $6,522,000.

Question 5. Fifteen percent of the responding districts indicated that they mix additives with their fuel oil, 69 percent said they do not, and 16 percent did not answer, presumably because they do not use fuel oil.

Question 6. In 67 percent of the districts, one person has overall responsibility for supervising the maintenance of equipment. In 73 percent of these districts, no written status reports are sent by the schools to the district maintenance supervisor. Weekly reports are sent in 2 percent of the districts, monthly reports were reported in 3 percent of the districts, yearly reports in 8 percent, and "other" in 14 percent.

## MINNESOTA SCHOOL SURVEY

## MAINTENANCE OF OPERATING MECHANICAL EQUIPMENT IN MINNESOTA SCHOOL BUILDINGS

## LOCAL SCHOOL DISTRICT QUESTIONNAIRE

(To be completed by the local school district office staff)

Local School District Name ____________ School District Number ______

Name of Local District Superintendent ____________

Local District Office Telephone Number ______

---

1. Please list the number of schools in your local district that fall into the following categories:

   ______ Elementary
   ______ Four-year Secondary
   ______ Six-year Secondary
   ______ Junior Secondary
   ______ Senior Secondary
   ______ Area Vocational-Technical
   ______ Vocational Secondary

2. What was the total student enrollment in your district last year? ______

3. Please list all contracts issued by your district last year for the maintenance of operating mechanical equipment. (See definition on last page).

| Type of operating mechanical equipment covered by contract | Cost per year |
|---|---|
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |
| | |

(If more space is required, please use an additional sheet and attach to questionnaire.)

4. For each item listed below, please indicate the quantity used by your school district last year and the total cost of each.

| | |
|---|---|
| Gallons of fuel oil ______ | Total cost of fuel oil ______ |
| Cubic feet of gas ______ | Total cost of gas ______ |
| Tons of coal ______ | Total cost of coal ______ |
| Quantity of other fuel ______ | Total cost of other fuel ______ |

(OVER)

5. If you use any fuel oil, does your district mix additives with the oil (besides those already added by the fuel oil company)?

   ☐ Yes ☐ No

6. Does one individual in your district have over-all responsibility for supervising the maintenance of operating mechanical equipment? (See definition on last page.)

   ☐ Yes ☐ No

   If "No", skip to question number 7.
   If "Yes", please answer 6a through 6c.

   6a. How often does each school provide this district maintenance supervisor with written status reports on the condition of operating mechanical equipment?

   ☐ No written report
   ☐ Weekly
   ☐ Monthly
   ☐ Yearly
   ☐ Other (Please specify how often) ______

   6b. How often does the district maintenance supervisor submit written reports to the superintendent?

   ☐ No written reports
   ☐ Weekly
   ☐ Monthly
   ☐ Yearly
   ☐ Other (Please specify how often) ______

   6c. Is the district maintenance supervisor assigned to closely observe the various construction phases of new school buildings in your district?

   ☐ Yes ☐ No

7. Does your district provide maintenance personnel with manuals (other than equipment manuals from manufacturers) that include maintenance procedures for operating mechanical equipment? ☐ Yes ☐ No

8. Does your district provide regular training programs for maintenance personnel dealing with the maintenance and servicing of operating mechanical equipment? ☐ Yes ☐ No

   If "No", skip to question 9.
   If "Yes", please answer questions 8a through 8c.

   8a. How many hours of operating mechanical equipment training does each individual receive in the program? ______ Hours

   8b. How frequently are operating mechanical equipment training programs offered by your district? ______

   8c. Please describe the type and content of your operating mechanical equipment training program or programs.

FIGURE 14. LOCAL SCHOOL DISTRICT QUESTIONNAIRE

(If more space is required, please use an additional sheet and attach to questionnaire.)

9. Please place a check in the box preceding the statement below that most closely describes the system utilized in your school district.

The maintenance of operating mechanical equipment is performed by

☐ a. A maintenance staff operating out of a central shop
☐ b. Maintenance personnel permanently assigned in each school
☐ c. Outside companies on a contract basis
☐ d. Combination of a and b
☐ e. Combination of a and c
☐ f. Combination of b and c
☐ g. Combination of a, b, and c

THE FOLLOWING QUESTIONS SHOULD BE ANSWERED BY THE DISTRICT SUPERINTENDENT.

10. If standard maintenance schedules and records were developed for your district, do you think such forms would be useful to your staff in

10a. The planning of new schools? ☐ Yes ☐ No
10b. The improvement of maintenance in existing schools? ☐ Yes ☐ No

11. Do you think that additional training programs for the maintenance of operating mechanical equipment would improve the performance of your maintenance staff? ☐ Yes ☐ No

12. If you would like to receive a copy of the report summarizing the results of this study, please check here ☐

Definition: Operating Mechanical Equipment -
Equipment having moving parts that are actuated by a power source; for instance, unit ventilators, heating and ventilating control systems, clock and bell systems, elevators, refrigeration systems, electric motors, automatic dishwashers, garbage disposers, etc.

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FIGURE 14. (CONTINUED)

Reports from the district maintenance supervisor to the district superintendent are made on a weekly basis in 3 percent of the districts, on a monthly basis in 6 percent of the districts, on a yearly basis in 9 percent, and "other" in 14 percent of the districts. Sixty-eight percent of the districts state that no written reports are submitted.

Thirty-five percent of the respondents to Question 6c report that the district maintenance supervisor is assigned to observe closely various construction phases in new school buildings.

Question 7. Thirty-five percent of the districts report that they provide maintenance personnel with manuals that include maintenance procedures, 63 percent do not, and 2 percent did not reply.

Question 8. Eleven percent of the districts state that they provide regular training programs for maintenance personnel, 87 percent do not, and 2 percent did not answer. On the average, maintenance personnel in the districts with training programs receive 20.8 hours of training.

Seventy percent of the districts that have regular training programs also provide the maintenance personnel with manuals describing maintenance procedures. By comparison, only 31 percent of the districts that do not have a training program provide such manuals.

The training programs reported in Question 8c were not detailed. A large portion of the districts reporting did not provide the courses at regularly scheduled intervals. Courses were attended only when they were offered in nearby towns. A substantial number of the training programs were actually brief courses presented by various factory equipment representatives.

Question 9. The types of maintenance systems used in school districts are presented in Figure 15. The most frequently used system is the one in which permanently assigned personnel perform the maintenance. Undoubtedly, in the majority of these schools, this head maintenance man also performs custodial duties. The second most widely used system (f) is one in which the work of maintenance men permanently assigned in each school is supplemented by outside companies on a contract basis.

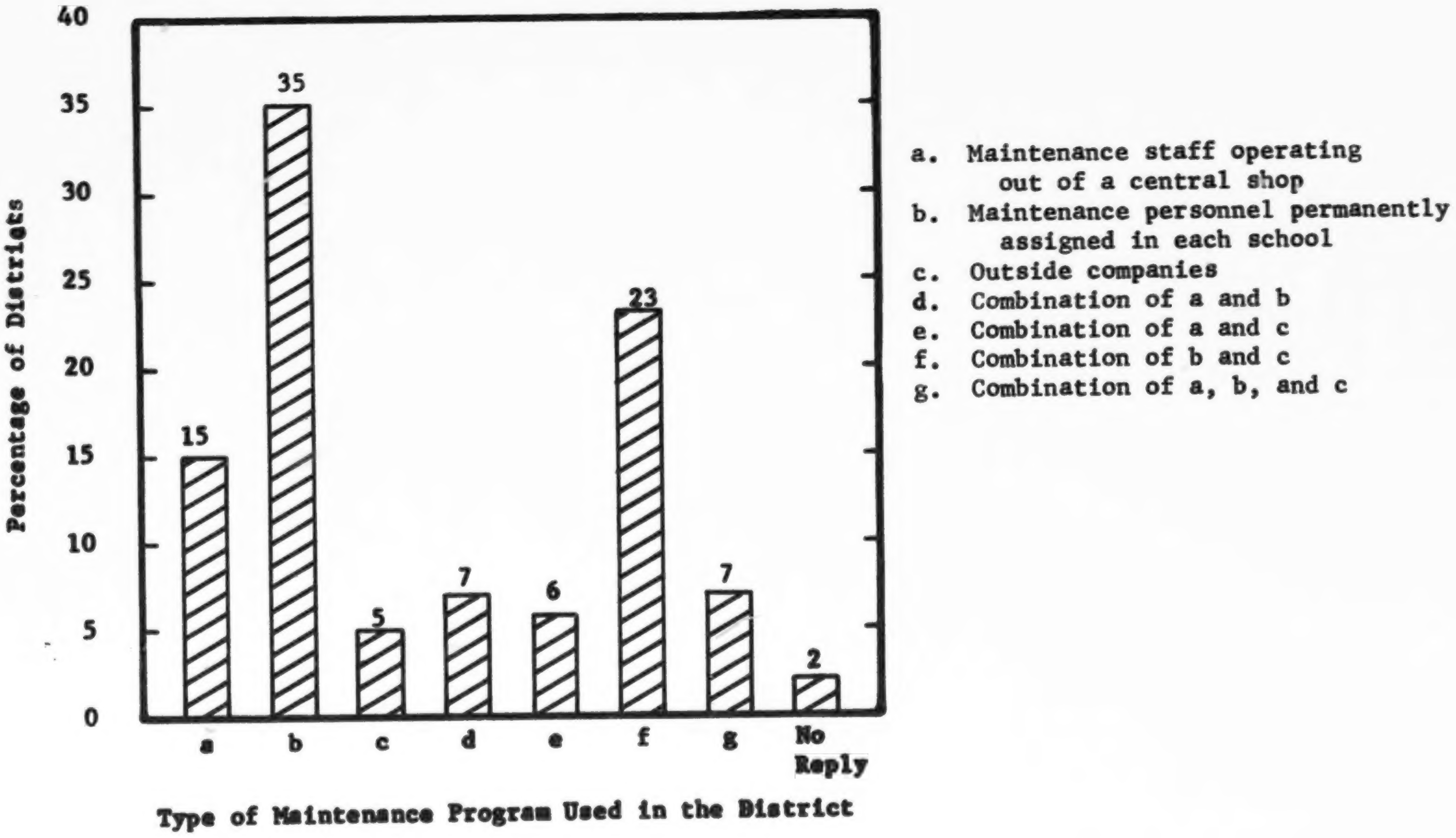


FIGURE 15. TYPES OF MAINTENANCE PROGRAMS USED IN THE RESPONDING DISTRICTS

Question 10. Of those that answered the questions, 78 percent think that standard maintenance forms and records would be useful for the planning of new schools, and 22 percent thought they would not be useful. Eighty-six percent thought that such forms and records would be useful in improving the maintenance in existing schools, and 14 percent thought not.

It is interesting to compare the responses to Questions 10a and 10b that are given by districts with and without a maintenance supervisor. Seventy-eight percent of the districts with a maintenance supervisor and 78 percent of the districts without a maintenance supervisor think standardized maintenance forms would help in planning new schools. Similarly, approximately 86 percent of the districts with a maintenance supervisor and 86 percent without one think such forms would help improve maintenance in existing school buildings.

Question 11. Eighty-six percent of the districts that returned this questionnaire believe that additional training programs for the maintenance of OME would improve the performance of their maintenance staff, 8 percent do not, and 6 percent did not express an opinion.

## ON-SITE VISIT PHASE

### Objectives and Selection of Schools to be Visited

The main objective of the on-site visits was to obtain maintenance information that was not readily obtainable through questionnaires and to verify some of the responses. It was believed that observations made by a qualified observer, even though not expressly concerned with the maintenance of a certain piece of equipment, could be correlated with the quality and ease of maintenance in the building. For example, an evaluation of the orientation of equipment in the boiler room can provide information about the relative ease of maintaining equipment, which is directly related to the quality of the maintenance procedures.

A total of 100 school buildings was visited during this phase of the study. These schools were selected on a partly geographic and partly random basis. School buildings in 77 of the 87 counties in the state were visited, with a larger number of buildings visited in counties that contained large centers of population, for example, Ramsey and Hennepin. After a county was selected, a town within the county was picked at random, and a particular school building in this town was chosen for the on-site visit. The particular school building to be visited was not always selected at random. An attempt was made to obtain a broad range of school classifications for the visits. Of the 100 schools visited, 33 were elementary, 40 were secondary, 26 were combinations of elementary and secondary, and one was a vocational school.

The original date of construction of the buildings visited, for which such information was known, is shown in Figure 16. The average year of construction for those buildings visited was 1936. It should be noted, however, that a large portion of the older schools have had one or more additions since their original date of construction, and, therefore, the average age of all schools visited is somewhat less than would be indicated by the 1936 original construction date.

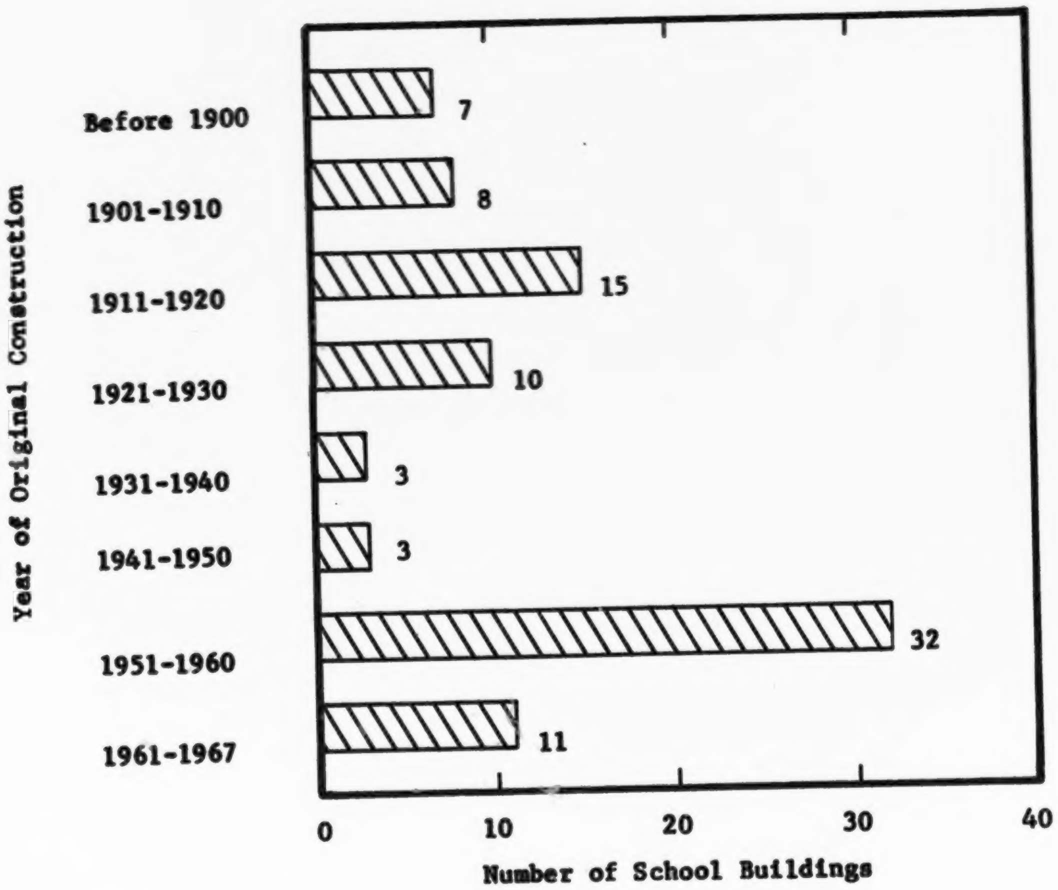


FIGURE 16. YEAR OF ORIGINAL CONSTRUCTION OF SCHOOL BUILDINGS VISITED

A condensed version of the On-Site Visit Form that was utilized to record comments and observations is shown in Figure 17. In the form actually used, space was provided for comments after each item. The form has been divided into two broad categories; (1) Boiler Room, and (2) General. A rating, ranging from one for excellent to four for poor, was given to many of the items listed in these two categories by the on-site observer. Other items merely required a yes or no response, and comments when necessary.

MINNESOTA SCHOOL SURVEY

MAINTENANCE OF OPERATING MECHANICAL EQUIPMENT
IN MINNESOTA SCHOOL BUILDINGS

## ON-SITE VISIT

Date of visit________________ District Code________________

Local District Number____________ Building Code________________

School Building Name____________ Date Constructed______________

Address________________________ City__________________________

Head Custodian__________________ Telephone Number______________

Principal_______________________

Time Started____________________

Time Finished___________________

Weather

Temperature________________

Wind_______________________

Cloud Cover________________

Precipitation______________

Code: 1-Excellent 2-Good 3-Fair 4-Poor

---

I. Boiler Room

1. Overall cleanliness 1 2 3 4
2. Lighting arrangement 1 2 3 4
3. Equipment Orientation 1 2 3 4
4. Space Allocation 1 2 3 4
5. General piping arrangements as related to equipment operation and maintenance. 1 2 3 4
6. Adequate valves 1 2 3 4
7. Adequate unions 1 2 3 4
8. Insulation and pipe covering--general condition 1 2 3 4
9. Primary water pumps 1 2 3 4
   (Elevated bases, proper piping supports, flexible piping connectors)
10. Boiler room ventilation 1 2 3 4
11. Adequate floor drains Yes No
12. Water sample taken of
    - 12a. boiler water Yes No
    - 12b. supply water Yes No
13. Stack gas sample taken Yes No

Burette Readings

| %Loading | $CO_2$ | $O_2$ | CO |
|---|---|---|---|
| ______ | ______ | ______ | ______ |

14. Stack gas temperature taken Yes No
    temperature_______$^{o}F$ percent loading_________
15. Cleanliness of boiler flues 1 2 3 4 Not Available
16. Condition of water column and gage glass 1 2 3 4
17. Boiler log up-to-date Yes No
18. When was the boiler relief valve last checked?________________
19. Compressor receiver tank drained Yes No
20. Hot water heater drawn down periodically Yes No
21. Hot water heater safety pilot check
    Operational Not operational
22. Circle type of pumps in this school
    Vacuum Condensate
    Condition of these pumps 1 2 3 4
23. Condition of steam traps 1 2 3 4
24. Condition of hot water recirculating pumps 1 2 3 4
25. Condition of fuel oil pumps 1 2 3 4
26. Condition of oil gage 1 2 3 4
27. Condition of oil strainers and filters 1 2 3 4
28. Condition of induced draft fans 1 2 3 4
29. Condition of incinerator or burner 1 2 3 4
30. Condition of temperature control panel board 1 2 3 4
31. Condition of hydro pneumatic tank and air compressor 1 2 3 4

II. General

1. Toilet room conditions 1 2 3 4
2. Toilet room ventilation 1 2 3 4
3. Automatic diswashers (when operating)
   Wash temperature________$^{o}F$
   Rinse temperature_______$^{o}F$
4. Quality of maintenance records 1 2 3 4 No records
5. List any equipment that is out of repair, not working properly, or not working at all. Why is it out of repair?
   Equipment and comments:
   ________________________________________
   ________________________________________
   ________________________________________
   ________________________________________
   ________________________________________
   ________________________________________

FIGURE 17. ON-SITE VISIT FORM

6. Equipment that causes most difficulties in this school (ask head custodian)

Equipment and type of difficulty:

7. How many man-hours per week are spend on maintenance of OME in this school?

_________Hours

Definition: Operating Mechanical Equipment-
Equipment having moving parts that are actuated by a power source; for instance, unit ventilators, heating and ventilating control systems, clock and bell systems, elevators, refrigeration systems, electric motors, automatic dishwashers, garbage disposers, etc.

8. Is staff provided with maintenance manuals for OME in this school?

Yes No

8a. If "yes", how good are the manuals with regards to clarity and completeness?

9. Classroom unit ventilators

9a. Quietness of operation 1 2 3 4

9b. Condition of air filters 1 2 3 4

9c. General operating condition of unit 1 2 3 4

10. Condition of roof exhaust fans 1 2 3 4

11. Condition of central ventilation system 1 2 3 4

12. Condition of hardware, door closers, locks, etc. 1 2 3 4

13. General Observations

14. Overall Maintenance Condition of building.

FIGURE 17. (CONTINUED)

The general guidelines used by the on-site observer in assigning a rating from "poor" to "excellent" are as follows:

| | |
|---|---|
| Excellent -- | This rating indicated that the condition of a piece of equipment was as good as could be expected in relation to its age and operating environment. The condition of the equipment could not be significantly improved. |
| Good -- | This rating indicated that some improvement in the condition of a piece of equipment could be made. Improvement of the maintenance practices for this equipment would be desirable and helpful. |
| Fair -- | This rating indicated that the piece of equipment was in a moderately substandard state of repair in relation to its age and operating environment. Improvement of the maintenance practices for this equipment is necessary. |
| Poor -- | This rating indicated that the piece of equipment was in an extremely substandard state of repair. Improvement of the maintenance practices for this equipment is of critical importance. |

A tabulation and discussion of the responses and observations for each item listed in the On-Site Visit Form is presented in the following paragraphs.

## Results of Visits

### Boiler Room

Item 1. The overall cleanliness of the boiler room, even though not directly related to the maintenance of OME, provides one means of evaluating the capabilities of the school maintenance staff. The boiler room in many of the school buildings visited was found to be cluttered with trash, yard sprinklers, hose, boiler compounds, boxes, etc., scattered over various sections of the room. In many instances, oil and water leakage on the floors was observed. In contrast to such conditions, the floors were sealed and waxed in several boiler rooms, and equipment was dusted or cleaned on a daily basis. Some of the boiler rooms were poorly arranged, creating difficulties in proper cleaning and maintenance.

Many examples of poor cleaning practices were observed, some of which are shown in Figure 18. Figure 18A is a picture of what was perhaps the dirtiest boiler room seen during the on-site visits. Poor housekeeping procedures can be noted in the floor leakage stains shown in Figure 18B. Also, note that the temperature control compressor is not equipped with a belt guard. This is a hazardous situation and can cause serious personal injuries. Figure 18C and 18D show some of the generally poor housekeeping conditions found in two of the school buildings.

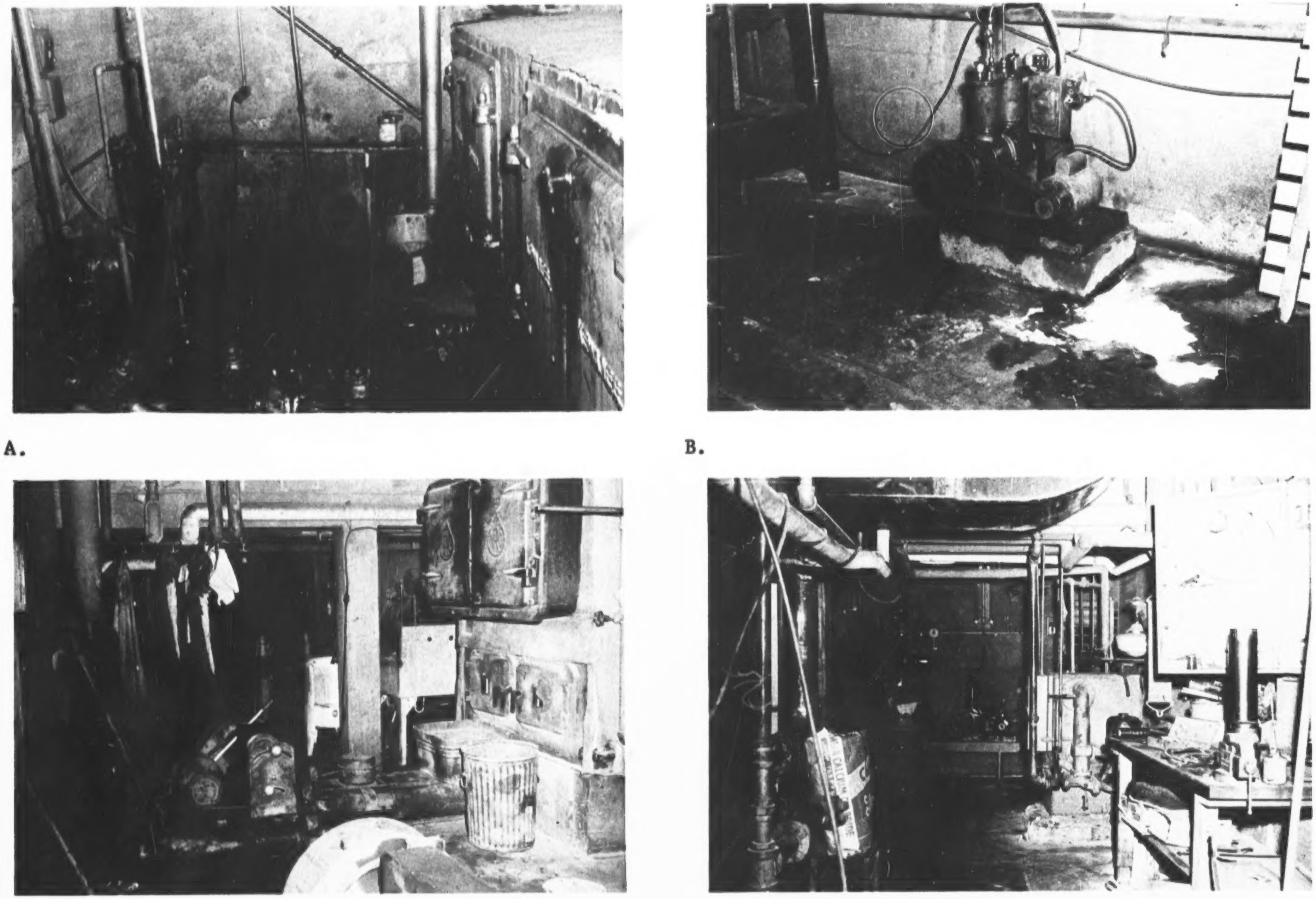
Several examples of neat, well-maintained boiler rooms are shown in Figure 19. Note the well-marked and easily identifiable piping arrangement in Figure 19A. Also, note the cleanliness of the two fuel oil pumps. Figure 19B shows a well-kept boiler room that has adequate space for equipment maintenance. Figures 19C and 19D show a well-maintained boiler burner arrangement and hot water tank.

Of the schools visited, 30 percent were rated as excellent in overall cleanliness, 30 percent good, 24 percent fair, and 16 percent poor.

Item 2. The lighting arrangement in the boiler room reflects mainly the design characteristics of the building and is not directly related to the quality of maintenance of the building. However, the poorly lighted boiler room creates many difficulties for the engineer who is trying to perform his duties effectively. The lighting arrangement found in many of the boiler rooms left much to be desired. In some cases, improvised lighting was provided by light bulbs on long extension cords. In other cases, all of the lighting was located on the ceiling, and sections under equipment on the floor level were in almost total darkness. Poor lighting conditions in some of the boiler rooms caused difficulty in reading instruments such as the water gages. Several of the boiler rooms were designed and built so that they would take advantage of good natural lighting from outside.

Sixteen percent of the schools visited were rated as excellent in lighting arrangements, 40 percent good, 31 percent fair, and 13 percent poor.

Item 3. Equipment orientation can be of importance in determining the ease and frequency with which boiler room maintenance tasks are performed. The poorly designed or overcrowded boiler room is not conducive to proper maintenance practices. A large percentage of the boiler rooms were observed to be overcrowded. In some instances, equipment was located in several rooms remote from one another causing maintenance difficulties. The vacuum and condensate return pumps in some buildings were located in tunnels less than four feet in height. The difficulties of servicing such equipment are obvious. In many instances, the heating coils on hot water heaters were so located as to make it impossible to remove them for cleaning



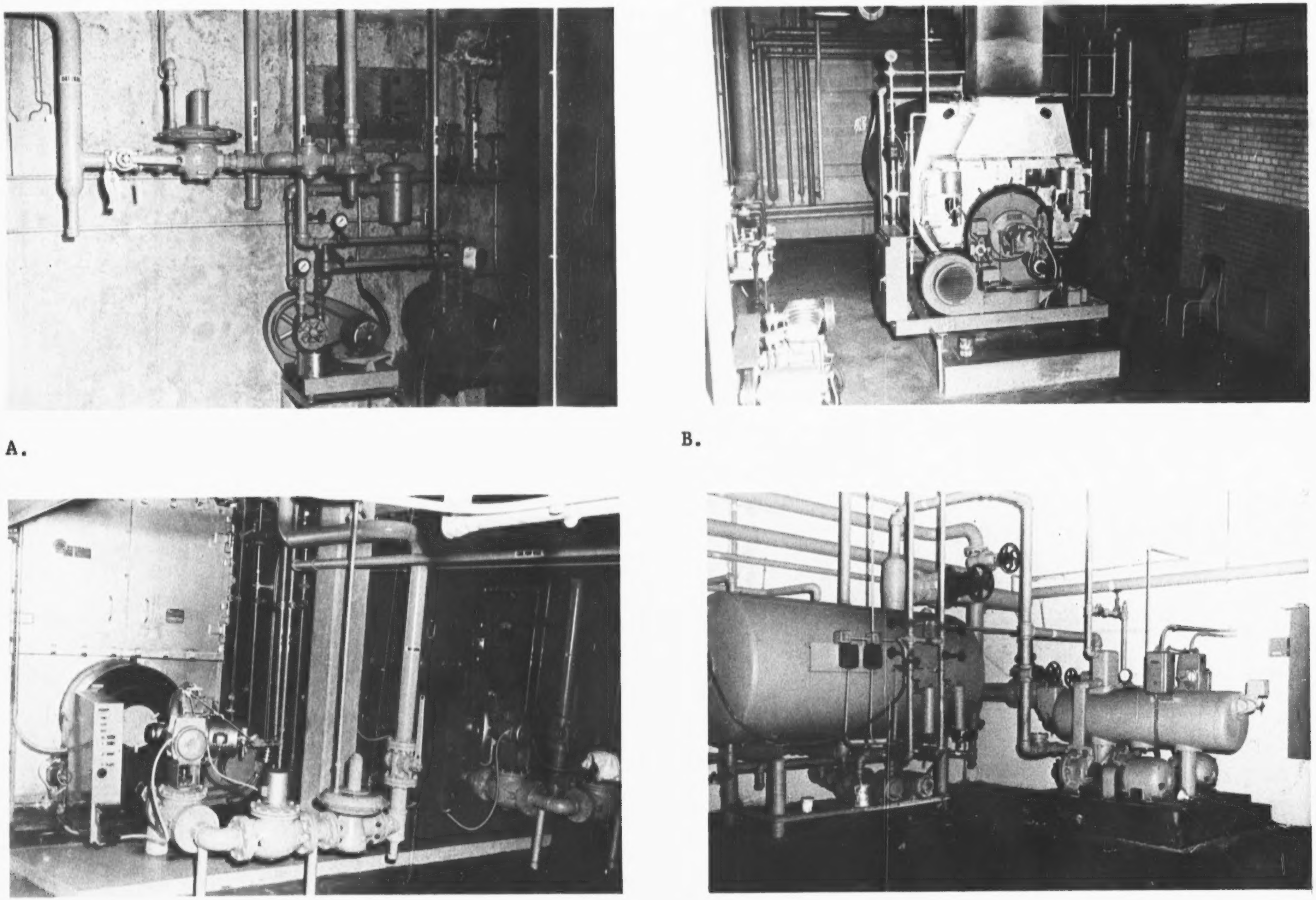
A.

B.

C.

D.

FIGURE 18. EXAMPLES OF POOR CLEANING PRACTICES



A.

B.

C.

D.

FIGURE 19. EXAMPLES OF WELL MAINTAINED BOILER ROOMS

or replacement without dismantling much piping or completely removing the heating unit. The boilers in several of the boiler rooms were set in pits in the floor, making servicing and repair difficult.

In many of the school buildings visited, the design and layout of the boiler room makes it difficult to maintain the mechanical equipment. For example, comparing Figures 20A and 20B, one notes the relative inaccessibility of the storage tank in the top, rear portion of 20B, as compared with 20A. The pumps shown in 20C are located for easy maintenance. However, the motors located under the piping in the bottom part of 20D are difficult to service.

Only 15 percent of the school buildings visited were rated as excellent in this category. Thirty-one percent were rated as good, 26 percent fair, and 28 percent poor.

Item 4. The allocation of space can be important for proper maintenance. Equipment that is "jammed" too close together or hidden in dark, inaccessible corners probably will not be properly maintained. In buildings to which additions have been made, the old boiler rooms tend to become crowded; additions to such rooms do not lend themselves to an efficient utilization of the space. However, even some recently constructed schools had poorly arranged boiler rooms. In one instance, with adequate floor area, equipment was jammed into one end, making maintenance difficult. In some buildings, the boiler rooms were originally designed for the addition of second or third boilers. The installation of the remaining boiler often will create crowded conditions in the boiler room.

Four examples of poor installation practices are shown in Figure 21. In Figure 21A, a ventilating unit was built in behind the large ductwork in the foreground, thus making servicing difficult. Note the two heating pumps at the top of Figure 21B. No valves were incorporated in the pipelines that are served by these pumps. Thus, the pumps cannot be removed for servicing or replacement without draining the hot water system. Figure 21C shows the lack of adequate space between two boilers for servicing piping and motors. Figure 21D is a picture of a frequently observed installation problem in storage tank water heaters. Heating coils extend into the tank where indicated by the clipboard. To remove these coils for cleaning or replacement, much piping (at the right side of the photograph) must be dismantled.

Fourteen percent of the schools visited rated excellent in space allocation, 37 percent good, 24 percent fair, and 25 percent poor.

Item 5. Sections of piping in some of the school buildings are inaccessible and difficult to maintain. Valves were sometimes located too high on the wall without catwalks, reachable only by ladder. In several schools, the hot water heater coils could not be removed except by completely dismantling the heater or by removing large amounts of piping (for example, in Figure 21D).

Only 13 percent of the schools visited rated excellent in general piping arrangements, 35 percent good, 35 percent fair, and 17 percent poor.

Items 6 and 7. The proper maintenance of many pieces of equipment in the boiler room requires that they occasionally be isolated, lubricated, disassembled, and replaced, without interrupting the operation of other pieces of equipment in the room. Consequently, an adequate number of valves and unions should be incorporated into the design and construction of school buildings. A lack of adequate valves in one building made it impossible to repair steam traps without a complete shutdown of the system. In many instances, valves showed evidence of a leaky packing or external corrosion. In another building, the maintenance men have to shut down the entire water system for the building to change a faucet on a drinking fountain.

Twenty-seven percent of the school buildings visited rated excellent in the category of adequate valves. Fifty-one percent rated good, 15 percent fair, and only 7 percent were rated poor. Twenty-seven percent of the schools rated as excellent with regard to adequate unions. Forty-eight percent rated good, 15 percent fair, and 10 percent were rated as poor.

Item 8. Another indication of the quality of overall maintenance is the condition of pipe insulation in the boiler room. Rotten and deteriorating covering indicates a lack of proper preventive maintenance practices. In several school buildings, the boiler covering was found to be loose, owing either to improper installation or careless washing down of the boiler room. In many cases, insulation on the hot and cold water piping was badly deteriorated or mildewed.

The water softener shown in Figure 22A is fouled and has obviously received little, if any, maintenance. There is considerable deterioration of the pipe covering in the vicinity of the water softener shown in Figure 22B. The boiler covering in 22C indicates a lack of maintenance. The vacuum pump shown in Figure 22D is rusted and corroded.

The insulation and pipe covering was rated as excellent in 29 percent of the school buildings, good in 43 percent, fair in 20 percent, and poor in 8 percent.

Item 9. Seventeen of the 100 buildings visited were equipped with water supply pumps. In several buildings, the pump was noisy, indicating a probable worn bearing. In some instances, no flexible connections were provided between the pump stage and its mounting area.

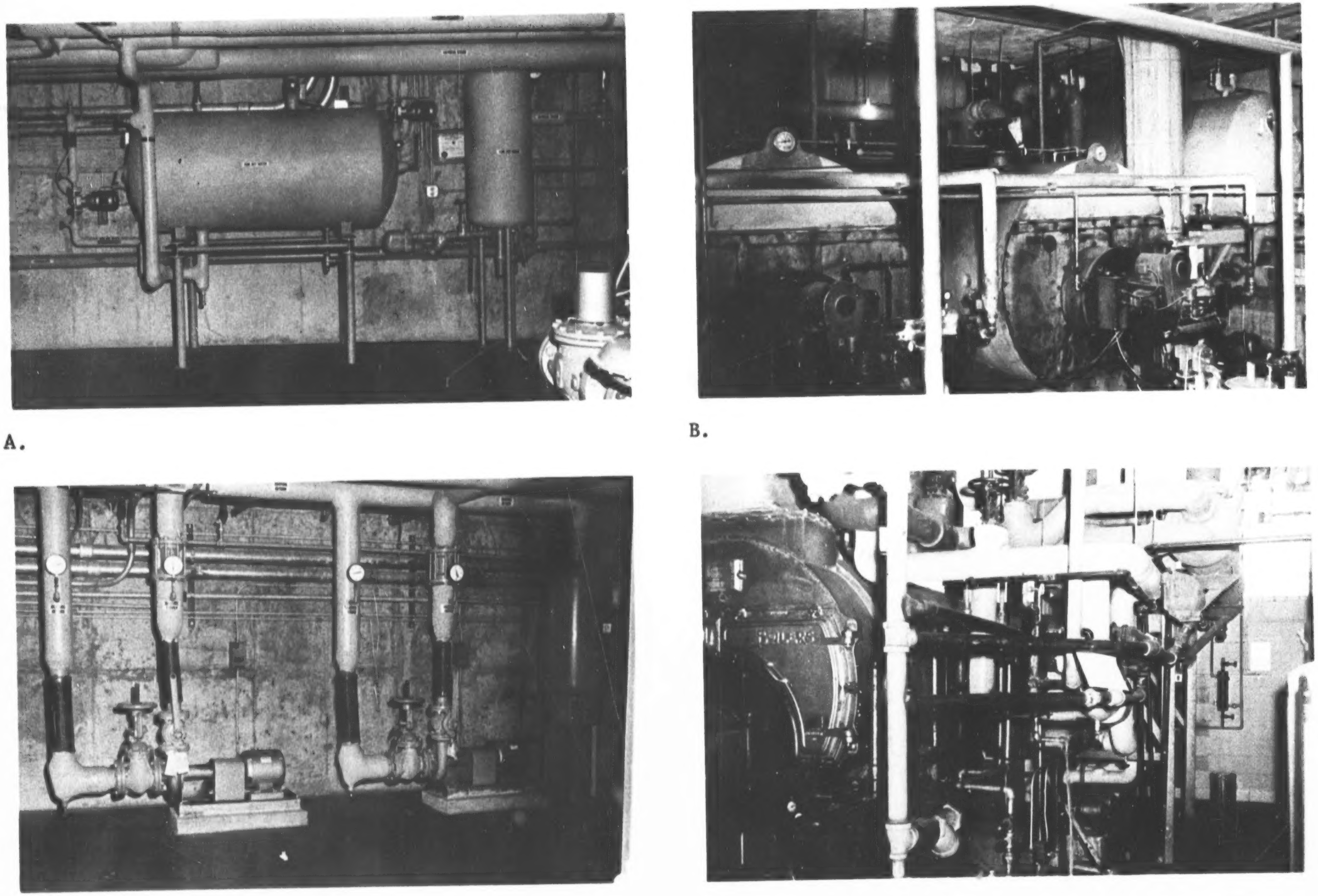
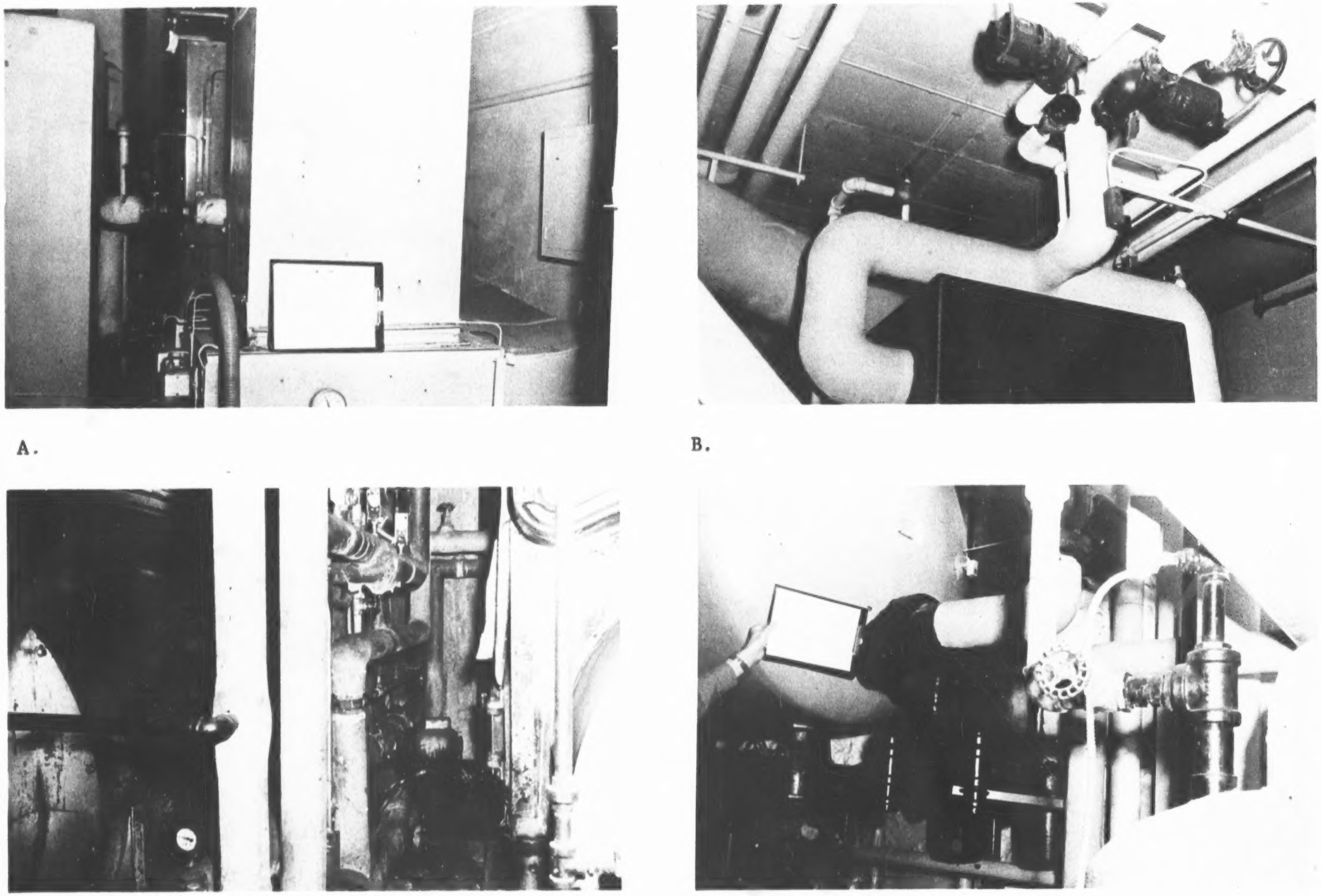


FIGURE 20. EXAMPLES OF GOOD AND POOR EQUIPMENT LOCATION



A.

B.

C.

D.

FIGURE 21. EXAMPLES OF POOR INSTALLATION PRACTICES

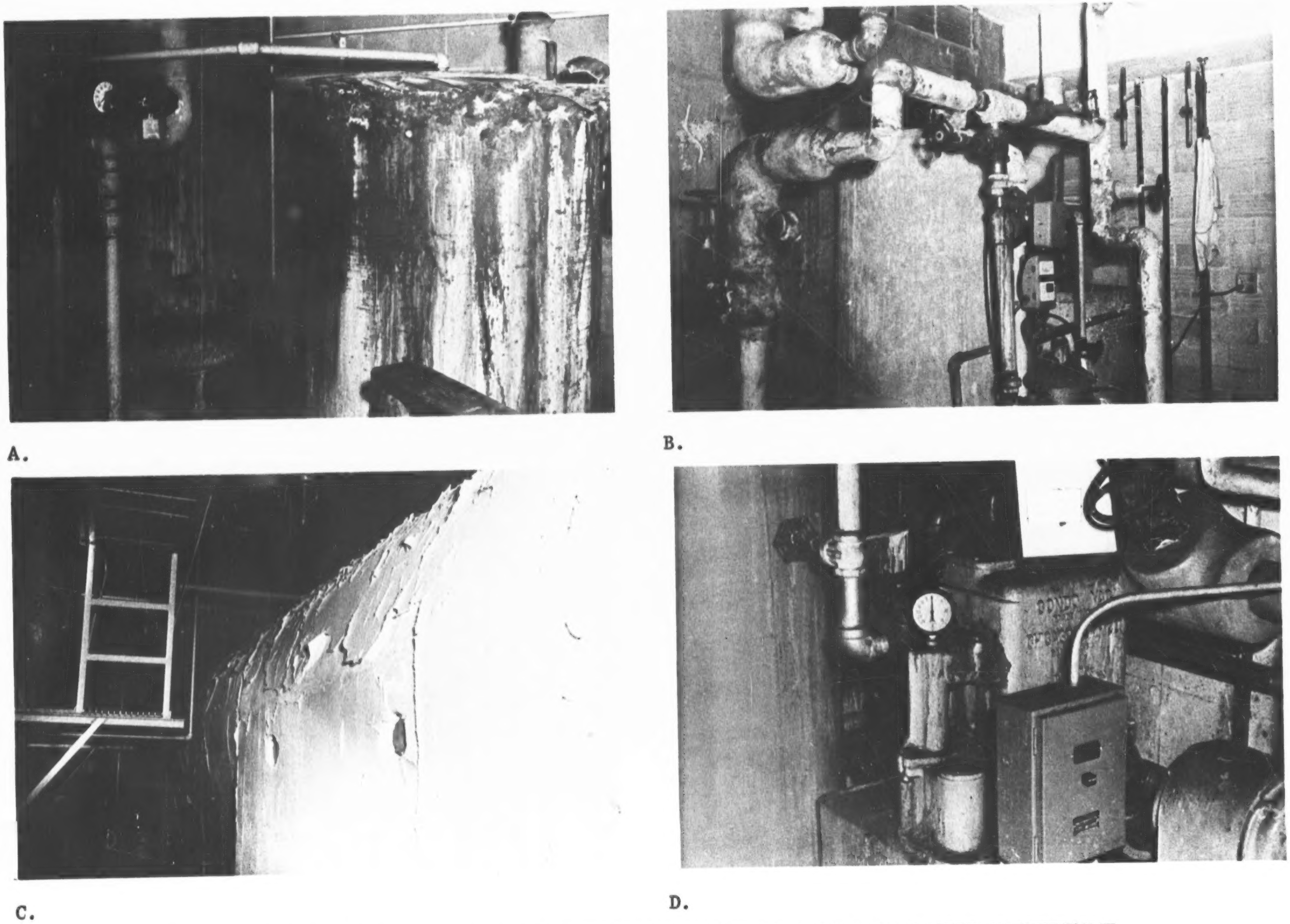


FIGURE 22. EXAMPLES OF EQUIPMENT DETERIORATION CAUSED BY A LACK OF PROPER MAINTENANCE

Of these buildings, 47 percent were rated excellent, 18 percent good, 29 percent fair, and 6 percent poor.

Item 10. Poor ventilation of the boiler room makes it uncomfortable, creating an atmosphere that is not conducive to performing proper maintenance on boiler room equipment. Many boiler rooms were observed to be warm or hot and, in a few cases, the boiler room was found to be much too cold. In a couple of cases, water was found frozen on the floor. In one building, the custodian complained about a locker room ventilation unit. Investigation showed that the outside air intake to this unit passed through the boiler room. The previous operator had blocked off the outside louver and cut a hole in the duct in the boiler room. This unit was then taking all of its air from the boiler room, creating a negative pressure and causing severe flashback of the burner flame during boiler startup. The screen and louvers on combustion air intakes were frequently found to be almost completely plugged with dirt, leaves, etc. The outside air dampers in many boiler rooms were found inoperative; proper ventilation was obtained only by opening doors and windows.

Of the schools visited during this phase of the project, 13 percent rated excellent in ventilation, 39 percent good, 14 percent fair, and 34 percent poor.

Item 11. In some of the buildings visited, hoses were found running over the floor to direct water to the floor drains. In many cases, the floor was poorly pitched, causing areas of water to remain standing around items of equipment. Such a condition can be dangerous by leading to falls and injuries.

Fifty-one percent of the schools visited were equipped with adequate floor drains, and 49 percent were not.

Item 12. Boiler and piping problems are frequently related to poor local water conditions and inadequate water treatment procedures. It was decided early in the program that random samples of boiler and supply water should be taken in a number of the school buildings visited. Water samples were, therefore, taken in 41 of the 100 schools visited. Boiler and supply water samples were then analyzed for 25 of these buildings. This analysis included measurements of the total hardness, the pH, the iron content, and the chloride content. In one building, the boiler operators had water test kits and checked the boiler water on a daily basis. However, in many other buildings, the boiler water was observed to be very dirty, indicating inadequate blowdown procedures. In some schools, the operators reported having problems with liming up and iron content of the water.

Although water chemistry is not as critical for low-pressure heating boilers as it is for industrial boilers operating at pressures of 100 psi or more, the long-term effects of improper water quality can, and do, result in unnecessary cost to the school.

The important observations in the analysis of such water, and points for comparison with the supply, are these:

- pH - measures available alkalinity
- Hardness - measures tendency to form scale
- Iron (soluble) - measures corrosion of steel that has already occurred
- Chlorides - measures salinity of water and is related to corrosiveness

Corrosion inhibitors are included in proprietary boiler compounds. Sulfites and chromates are commonly used. Our analysis did not include such tests, because on-site analysis is advisable.

To determine the typical level of quality of operational control with regard to boiler and hot water system operation, we tabulated the results of analyses from 25 randomly selected schools (Table 8), where both tap water and boiler water were sampled. The indications from these results are that:

- In 44 percent (11 out of 25) of Minnesota schools, excessive iron content shows up in the boiler water, indicating corrosion has taken place.
- In 72 percent (18 out of 25) of Minnesota schools, excessive chloride is found in the boiler water. Excessive chloride indicates an excess amount of makeup water is being used. Excess makeup water may be caused by poorly maintained steam traps, or other malfunctions, and produces conditions leading to corrosion and system failure in the future.
- In 28 percent (7 out of 25) of Minnesota schools, inadequate pH elevation is provided either by lack of or improper boiler compound application.
- In 29 percent (4 out of 14) of Minnesota schools equipped with water softening units (for scale prevention), the equipment is not producing softened water.

The conclusion to be drawn from these findings is that the water chemistry of boiler operation is in need of more attention to prevent premature failure of heating system components.

TABLE 8
WATER AND BOILER FLUE GAS ANALYSES

| School Number | Water Data | | | | | | | | Flue Gas Data | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PH | | Hardness (Grains/ Gallon) | | Iron (Milligrams/ Liter) | | Chlorides (Milligrams/ Liter) | | Fuel | $CO_2$ (%) | Temperature (°F) | Heat Loss (%) | Excess Air (%) |
| | Tap Water | Boiler Water | Tap Water | Boiler Water | Tap Water | Boiler Water | Tap Water | Boiler Water | | | | | |
| 1 | 8.20 | 11.05 | 8.20 | 1.25 | 0.80 | 4.40 | 0.5 | 22.0 | - | - | - | - | - |
| 3 | 7.85 | 9.90 | 14.60 | 3.90 | <0.05 | 3.80 | 2.0 | 8.0 | Oil | 6.2 | 575 | 24.0 | 143 |
| 4 | 7.40 | 11.30 | 4.95 | 0.60 | <0.05 | 1.85 | 13.0 | 14.5 | Gas | 7.3 | 295 | 7.8 | 60 |
| 5 | 7.80 | 11.40 | 15.90 | 0.50 | 0.50 | 1.80 | 2.0 | 3.5 | Gas | 5.4 | 525 | 18.6 | 113 |
| 6 | 8.30 | 11.65 | 16.00 | 0.45 | 0.05 | <0.05 | 3.0 | 23.0 | Gas | 8.4 | 320 | 7.3 | 40 |
| 7 | - | - | - | - | - | - | - | - | Oil | 12.4 | 455 | 9.5 | 24 |
| | | | | | | | | | Gas | 12.4 | 455 | 7.0 | 0 |
| 8 | - | - | - | - | - | - | - | - | Oil | 9.5 | 640 | 17.6 | 60 |
| 13 | 7.90 | 11.50 | 12.60 | 2.50 | <0.05 | 26.00 | 11.0 | 46.0 | Gas | 11.8 | 390 | 6.4 | 3 |
| 14 | 8.55 | 10.40 | 5.40 | 1.40 | <0.05 | 45.00 | 10.0 | 40.0 | - | - | - | - | - |
| 15 | 7.30 | 10.80 | 3.40 | 2.50 | 0.30 | 2.00 | 2.0 | 13.0 | Gas | 7.4 | 415 | 10.8 | 58 |
| 20 | 8.00 | 11.40 | 12.00 | 1.00 | 5.60 | >20.00 | 8.0 | 8.0 | Gas | 4.8 | 340 | 13.5 | 138 |
| 22 | - | - | - | - | - | - | - | - | Oil | 12.1 | 360 | 7.8 | 27 |
| 23 | - | - | - | - | - | - | - | - | Gas | 7.7 | 395 | 9.8 | 52 |
| 25 | - | - | - | - | - | - | - | - | Oil | 9.9 | 435 | 11.3 | 53 |
| 27 | 8.50 | 11.00 | 6.00 | 3.00 | <0.05 | 0.10 | 5.0 | 18.0 | Gas | 8.0 | 500 | 12.0 | 47 |
| 30 | - | - | - | - | - | - | - | - | Oil | 13.2 | 720 | 14.3 | 17 |
| 31 | 7.45 | 10.40 | 2.80 | 0.80 | 0.10 | 1.80 | 3.0 | 12.0 | Oil | 9.9 | 550 | 14.5 | 53 |
| 33 | - | - | - | - | - | - | - | - | Gas | 7.6 | 455 | 11.5 | 55 |
| 35 | 7.65 | 10.50 | 5.60 | 1.20 | 0.10 | 0.50 | 10.0 | 40.5 | Gas | 8.2 | 485 | 11.3 | 43 |
| 37 | 7.70 | 11.50 | 17.40 | 0.30 | 0.05 | 0.30 | 4.5 | 13.5 | Gas | 4.9 | 345 | 13.5 | 133 |
| 38 | - | - | - | - | - | - | - | - | Gas | 7.3 | 410 | 10.8 | 60 |
| 40 | 7.70 | 8.30 | 15.60 | 0.60 | <0.05 | 10.5 | 2.0 | 2.0 | Gas | 8.7 | 385 | 8.5 | 37 |
| 42 | - | - | - | - | - | - | - | - | Gas | 10.2 | 310 | 5.8 | 17 |
| 43 | 8.15 | 11.90 | 12.80 | 1.00 | 0 | 7.4 | 4.0 | 62.0 | Gas | 7.3 | 355 | 9.3 | 60 |
| 47 | - | - | - | - | - | - | - | - | Oil | 6.3 | 405 | 16.7 | 140 |
| 50 | 7.90 | 11.80 | 16.10 | 0.70 | 0.30 | <0.05 | 94.0 | 705.0 | Gas | 6.7 | 440 | 12.8 | 74 |
| 54 | - | - | - | - | - | - | - | - | Gas | 7.7 | 425 | 10.7 | 52 |
| 55 | 7.80 | 10.30 | 5.70 | 0.50 | <0.05 | 1.00 | 3.0 | 1.0 | Gas | 6.6 | 460 | 13.3 | 76 |
| 57 | 8.05 | 11.40 | 8.70 | 1.30 | 0.10 | 9.00 | 2.0 | 40.0 | Gas | 8.8 | 505 | 11.0 | 34 |
| 66 | 7.80 | 8.90 | 61.40 | 2.40 | 4.20 | 7.25 | 0 | 0 | - | - | - | - | - |
| 68 | - | - | - | - | - | - | - | - | Oil | 8.9 | 475 | 13.9 | 70 |
| | | | | | | | | | Oil | 8.6 | 435 | 13.2 | 76 |
| 71 | 7.95 | 11.85 | 21.60 | 0.80 | 0.05 | 1.00 | 20.0 | 106.0 | Gas | 9.1 | 340 | 7.2 | 30 |
| 77 | 7.70 | 11.45 | 15.80 | 1.20 | 0.35 | 0.75 | 0.5 | 52.0 | Gas | 7.0 | 435 | 11.9 | 67 |
| 78 | 7.50 | 11.60 | 19.80 | 1.40 | <0.05 | 30.00 | 26.0 | 292.0 | Oil | 11.5 | 415 | 9.4 | 33 |
| 79 | - | - | - | - | - | - | - | - | Oil | 11.0 | 415 | 9.9 | 38 |
| 82 | 8.20 | 9.50 | 31.60 | 47.40 | 0.80 | 20.00 | 2.0 | 75.0 | Oil | 10.3 | 520 | 13.2 | 48 |
| 83 | 6.95 | 11.40 | 5.70 | 2.00 | 0.10 | 57.50 | 20.0 | 70.0 | Gas | 7.2 | 430 | 11.5 | 62 |
| | | | | | | | | | Oil | 9.7 | 440 | 11.8 | 57 |
| 85 | 9.05 | 11.65 | 9.30 | 1.30 | 0.15 | 6.75 | 26.0 | 530.0 | Gas | 6.7 | 410 | 11.8 | 74 |
| 87 | - | - | - | - | - | - | - | - | Oil | 8.5 | 425 | 13.0 | 78 |
| 95 | - | - | - | - | - | - | - | - | Gas | 4.3 | 245 | 11.0 | 165 |

Item 13. It was also decided early in the program that, whenever possible, a stack gas sample should be taken and analyzed in an attempt to establish the operating characteristics of the boiler or heating plant. Such a sample was taken in 36 percent of the schools visited.

A portable Burrell gas analysis apparatus (Model 39-507) was utilized to make these measurements. The flue gas was analyzed for carbon dioxide, oxygen, and carbon monoxide. From these measurements and the stack gas temperature, heat loss in the stack gas and the excess air can be estimated.

The percentage heat loss and percentage of excess air for all samples taken during the on-site survey are presented in Figure 23. Results of the flue gas analysis are tabulated in Table 8. Also shown in Figure 23 are the acceptable ranges for percentage of excess air for oil- or gas-fired boilers. Only two of the schools with oil-fired boilers and one with a gas-fired boiler fall in the recommended ranges. The majority of the school buildings are apparently operating the boilers with too much excess air. Reducing the amount of excess air to the recommended range will reduce the heat loss and increase the efficiency of the heating plant.

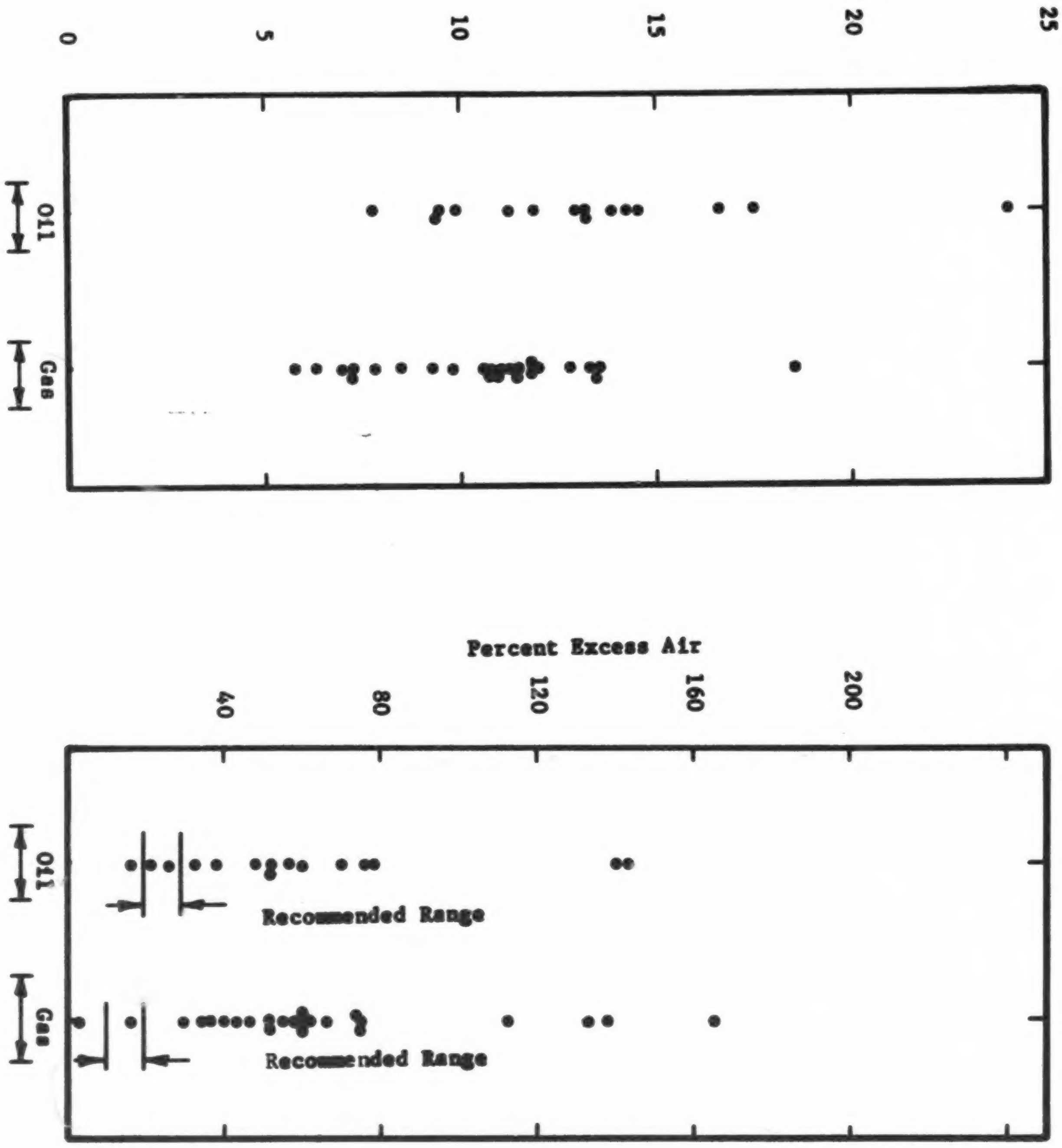


FIGURE 23. HEAT LOSS AND EXCESS AIR DATA FOR 36 SCHOOL BUILDINGS

The worst case measured during the on-site visits was with an oil-fired boiler operating with a stack gas temperature of 575°F, and an excess air of 143 percent. If the excess air was reduced to 28 percent, the heat loss would be reduced from 24 percent down to 12½, a factor of almost 50 percent. This change is very close to an increase in the boiler efficiency of roughly 12 percent. Such an improvement in boiler efficiency would, at a minimum, produce at least a 12-percent reduction in annual heating costs. The heating costs could be reduced even further if steps were taken to reduce the stack gas temperature by proper cleaning of the boiler flues and heat transfer surfaces.

Item 14. Stack gas temperatures were also taken in the 36 schools mentioned in the previous question. The recorded temperature ranged from a minimum of 245°F to a maximum of 720°F (Table 8). Once again, it should be pointed out that excessively high stack gas temperatures produce excessively large stack gas heat losses. The high flue gas temperature observed in some buildings can probably be attributed to a large accumulation of soot in the boiler flues and on the heating surfaces. In one building, the temperature indicated by an existing stack thermometer was found to be in error by over 200°F.

Item 15. In one of the buildings visited, reclaimed auto-engine oil was being burned in the boiler. The combustion chamber was coated with approximately a one-inch-thick layer of noncombustibles. If this practice is continued, these boilers may soon be ruined.

The cleanliness of the boiler flues was rated excellent in 28 percent of the schools, good in 26 percent, fair in 3 percent, and poor in 6 percent. It was not available or not easily determined in 37 percent.

Item 16. A dirty or cloudy boiler gage glass indicates improper maintenance attention. In a large number of the schools visited, the water column and gage glass was observed to be dirty, indicating poor

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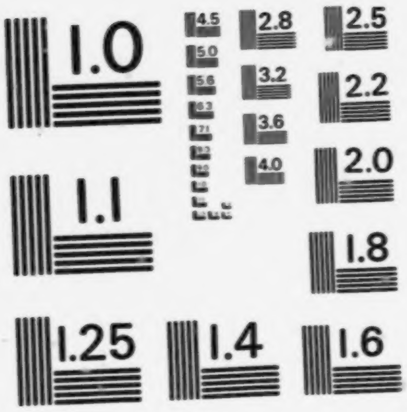
1.0
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6.3
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2.8
3.2
3.6
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1.25
1.4
1.6

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blowdown practices. Of the schools visited, 34 percent were rated excellent on the condition of the water column, 35 percent good, 18 percent fair, and 13 percent poor. Therefore, it would appear that the maintenance man in approximately 31 percent of the schools in the state is not performing this duty in the recommended manner.

Item 17. A boiler log can be helpful in detecting and correcting difficulties as they arise in the life of a boiler. Numerous authorities recommended that an up-to-date boiler log be maintained to provide the information required to maintain an efficient heating system. Of the 100 schools visited, only 26 percent maintain such an up-to-date boiler log. Seventy-four percent of the schools maintained either no log or a log that was not kept up-to-date and, therefore, of little value.

Item 18. According to discussions with the head maintenance man in each school, the boiler relief valve is checked daily in 19 percent of the schools, weekly in 18 percent, monthly in 5 percent, and on some other schedule in the remaining schools. In one school, the boiler relief valve did not seat properly and leaked steam.

Item 19. Only three percent of the schools visited failed to have a drained compressor receiver tank. The remaining 97 percent had performed this task at various intervals.

Item 20. Ninety percent of the schools visited indicated that they draw down the hot water heater periodically; 10 percent do not.

Item 21. A hot water heater safety pilot check was conducted in 49 of the 100 schools visited. The safety pilot was found operational in all cases.

Item 22. In many of the schools visited, the packing of the vacuum or condensate pumps was leaking badly. In many cases, the vacuum pump could not pull a vacuum on the system, possibly because of steam-trap troubles or piping leaks. In one school, daily checks are made of all condensate return temperatures as a means of determining steam-trap problems. Steam-trap problems were observed in some of the schools and, in one school in particular, the condensate was returning at an elevated temperature of 215$^o$, indicating faulty trap performance.

Of the schools visited, 78 percent used vacuum pumps and 22 percent had condensate return pumps. The condition of the pumps was rated excellent in 34 percent of the schools, good in 36 percent, fair in 12 percent, and poor in 18 percent.

Item 23. A properly maintained steam trap system is essential to obtain maximum efficiency from the heating plant. In many of the schools visited, the steam traps are repaired or replaced only when they fail, indicating a breakdown maintenance practice. In one school building, the operator had a piping arrangement in the boiler room for checking the operation of the school steam-trap system. In some school buildings with steam-trap problems, the head maintenance man reported that he just did not have enough time to repair them at present. Manufacturers suggest that a malfunctioning steam trap can result in a 14 percent loss in efficiency or a loss of 2½ cents per hour for each trap.

In 48 percent of the schools, the observer rated the steam-trap system as excellent, good in 32 percent, fair in 10 percent, and poor in 10 percent. These results indicate that in approximately 52 percent of the school buildings that utilize a steam heating system, the system is not operating at peak efficiency.

Item 24. A large number of spring coupling problems were observed on recirculating pumps in many of the schools. In some buildings, oil and water leakage was observed in these pumps. The condition of the hot water recirculating pumps was rated excellent in 42 percent of the school buildings, good in 46 percent, fair in 2 percent, and poor in 10 percent.

Item 25. Leaking oil was observed in some of the fuel oil pumps in a few of the buildings. In one case the solution was to place a large drip pan under the pump. In one instance, the fuel oil pump was noisy, probably indicating bearing problems.

In the 62 schools in which fuel oil pumps were present, the pumps are rated excellent in 48 percent, good in 36 percent, fair in 13 percent, and poor in only 3 percent.

Item 26. In a few of the school buildings, the oil gage was either broken or not operative. In particular, in one building, three out of four of the oil gages gave no registration or indication of oil level.

Of the same schools discussed in the previous question, the condition of the oil gage is rated excellent in 45 percent of the buildings, good in 44 percent, fair in 3 percent, and poor in 8 percent.

Item 27. The condition of oil strainers and filters was rated excellent in 49 percent of the school buildings visited that had such equipment, good in 43 percent, fair in 6 percent, and poor in 2 percent.

Item 28. As in other types of OME, bearing problems were also observed in the induced-draft fans in some buildings. In schools having an induced-draft fan, fan maintenance was excellent in 46 percent, good in 18 percent, fair in 18 percent, and poor in 18 percent.

Item 29. In many of the school buildings, the incinerator was far too small for practical use, and in some cases, actually of a residential size. In several instances, the incinerator was in a poor location.

Of the schools that have an incinerator or burner, the condition of this unit was rated excellent in 38 percent, good in 34 percent, fair in 10 percent, and poor in 18 percent.

Item 30. In two of the buildings visited, the temperature control system was inoperative on the night-cycle setting. In 47 percent of the school buildings visited, the condition of the temperature control panel board was rated excellent, good in 45 percent, fair in 6 percent, and poor in 2 percent.

Item 31. The hydropneumatic tank in one of the five buildings containing such a unit was very rusty. In another building, the tank exterior was also badly rusted, and in addition, the pipe covering was deteriorated. Of these schools, one was rated excellent, one was rated good, two were rated fair, and one was rated poor.

Further examples of poorly maintained equipment are shown in Figure 24. The boiler in one school building was corroded and had the water leak shown in 24A. In another building, a recirculating water pump had a leak that produced standing water on part of the boiler room floor (Figure 24B). The side walls were burned through in some parts of the incinerator shown in 24C. Even though the fire can be seen through the incinerator walls, the unit is still being used. The radiator covers shown in 24D have been bent and never repaired.

## General

Item 1. In several of the buildings visited, the toilet room was untidy, with wet floors, scattered paper towels on the floor, leaky faucets, cracked fixtures, leaky flush valves, and missing floor tiles. Much of the problem can be attributed to vandalism by the students. In a couple of cases, ceiling tile had actually been ripped loose, leaving an unsightly room.

The general condition of the toilet rooms was rated excellent in 37 percent of the schools visited, good in 40 percent, fair in 15 percent, and poor in 8 percent.

Item 2. A number of the schools visited had stuffy toilet rooms, frequently with strong, objectionable odors. In many instances, the ventilation was very poor, caused by inoperative ventilation units or clogged exhaust louvers. In one of the buildings, the door louver for makeup air had been broken and replaced with a plywood panel, leaving no air inlet.

Ventilation conditions in the toilet rooms were rated excellent in 38 percent of the schools, good in 25 percent, fair in 20 percent, and poor in 17 percent.

Item 3. In one of the buildings visited, live steam from the city steam plant was injected directly into the dishwasher. The operator was warned that this was a violation of the health codes and that it should be stopped immediately. The toxic boiler treatment compounds might be injected directly onto the food-serving equipment by this arrangement.

Of the 100 schools visited, 77 were equipped with automatic dishwashers. Of schools so equipped, the rinse water temperature was maintained at 180°F in 87 percent of the schools, and at temperatures ranging from 160° to 205° in the remaining 13 percent of the buildings.

Item 4. Maintenance records were kept in only 23 of the schools visited. Of these 23 schools, the quality of the maintenance records was rated as excellent in 6 of the buildings, good in 9, fair in 5, and poor in 3. These statistics thus indicate that only about 15 percent of the schools in the state keep good to excellent maintenance records.

Item 5. During the on-site visit phase of this project, many items of OME were observed to be out of repair. The most frequently found items that appeared to require some type or degree of repair were the boiler burner, steam traps, water heaters, vacuum pumps, ventilation units, unit heaters, central fans, and incinerators. In one school building, 75 spare water pumps are kept on hand for emergency. Of the 100 school buildings visited, 61 were found to have some equipment that was out of repair, not working properly, or not working at all.

Deteriorated ductwork covering can be noted in Figure 25A. A leaking fuel oil pump was observed in one building (Figure 25B, top and center of picture). Rather than fixing the faulty pump, the personnel have suspended a large pan beneath the pump to catch the dripping oil. Note the oil spillage on the wall

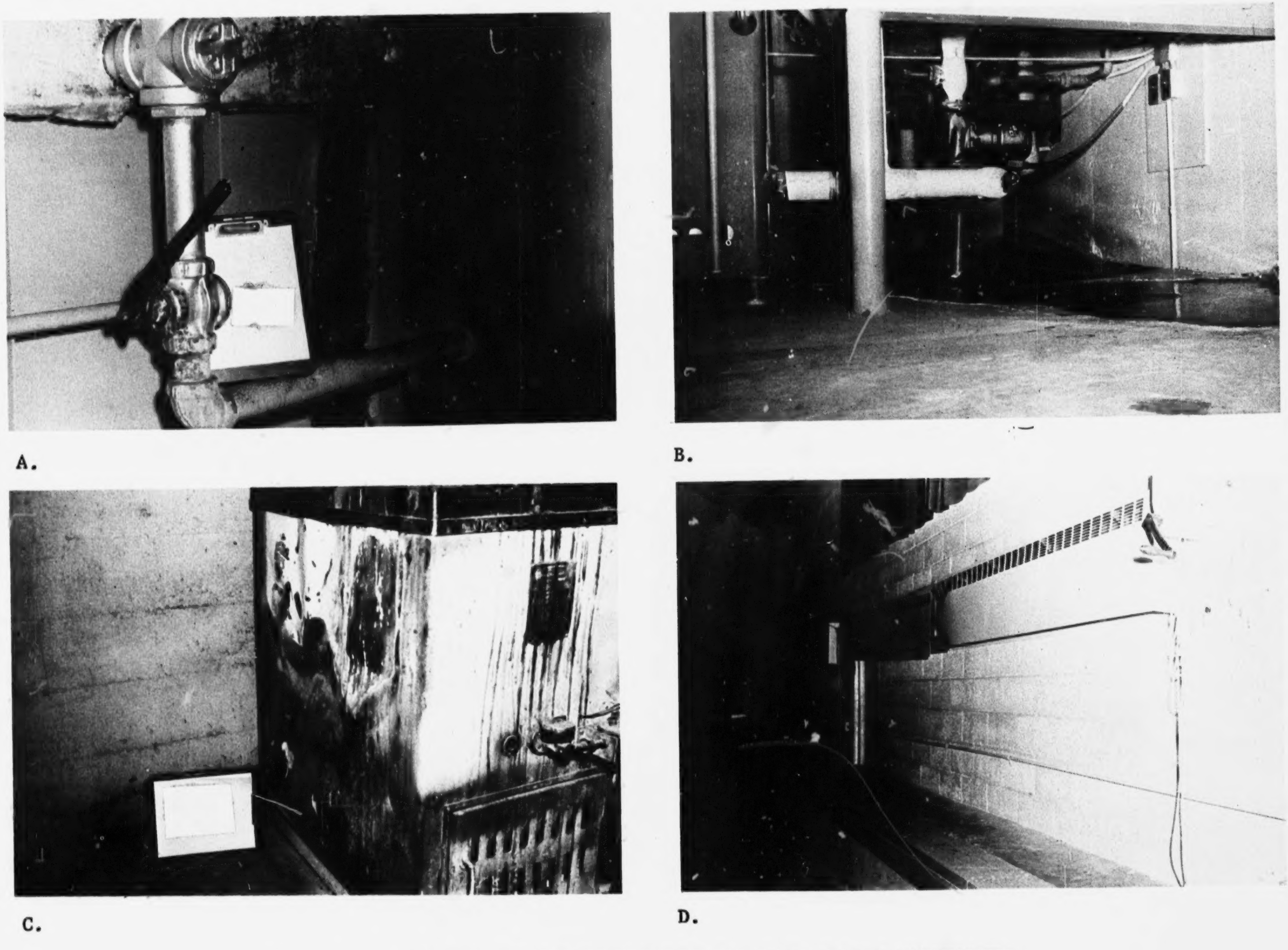
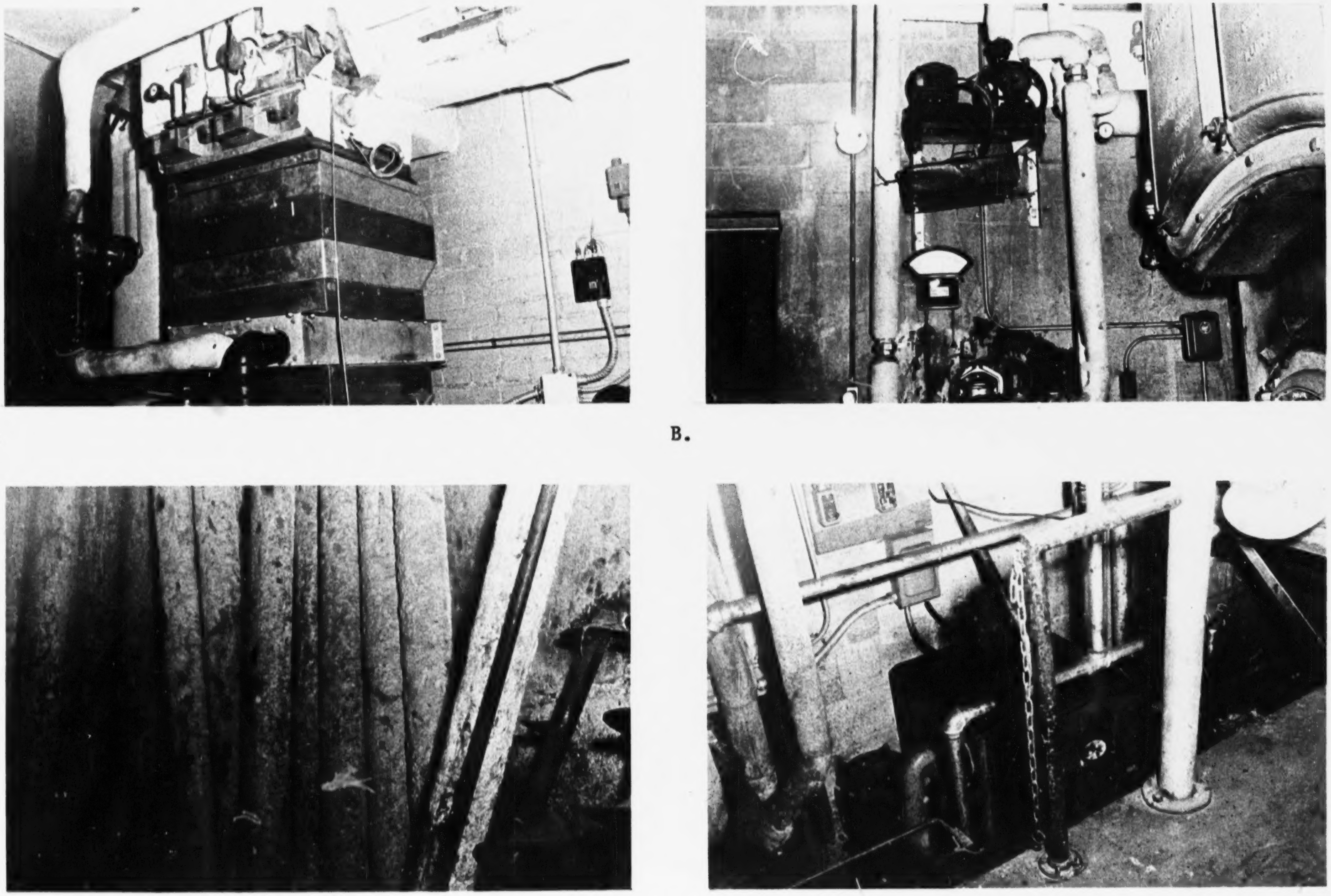


FIGURE 24. EXAMPLES OF EQUIPMENT THAT HAS BEEN POORLY MAINTAINED



A.

B.

C.

D.

FIGURE 25. EXAMPLES OF EQUIPMENT THAT HAS BEEN POORLY MAINTAINED

near the bottom of the picture. Several badly scaled boiler tubes, recently removed from the boiler in one school building, are shown in 25C. The condition of these tubes indicates a lack of proper boiler water treatment, leading to inefficient boiler operation. It is possible that such scaling would reduce the boiler efficiency by 25-50 percent with an increase in heating costs of possibly as much as 50-100 percent. Figure 25D shows a condensate pump, located in a deep pit, that appeared never to have been cleaned. Note the dirty gage near the bottom center of the picture. Also, note the uncovered switch box in the upper left portion of the picture. The lack of proper maintenance and cleaning can, to a large degree, be attributed to the lack of easy accessibility to the equipment.

Item 6. In a large number of the school buildings visited, both old and new, a definite lack of storage space was noted. The inaccessibility of various pieces of equipment for replacement and maintenance was another frequently observed condition.

The head custodian was requested to give the types of equipment that cause the most difficulty in his school for himself and his staff. A variety of answers to this question was received, but the most frequently found answers were unit ventilators, the boiler burner, the temperature control compressor, hot water heaters, piping, steam traps, controls (in general), the ventilating system, valves and plumbing.

Figure 26 shows several examples of how storage in boiler and mechanical equipment rooms creates maintenance difficulties. The valve and steam trap at the top center of Figure 26A are difficult to reach for servicing because of the stage equipment stored below. The pumps and piping in the background in 26B are inaccessible, owing to storage problems. Figures 26C and 26D also show the cluttered conditions created by inadequate storage space.

Item 7. Estimates of time spent on maintenance of OME ranged from only a few hours each week to full time. In many school buildings, the head custodian was not able to provide an accurate estimate of the number of hours spent per week.

Item 8. The custodial staff was provided with maintenance manuals for OME in 21 percent of the school buildings visited. Of those school buildings in which maintenance manuals were seen, approximately 50 percent appeared to be complete. In one instance, the head maintenance man had started his own file of equipment data. The on-site visits indicate, therefore, that only approximately 10 percent of the school buildings in Minnesota have adequate maintenance manuals.

Item 9. In several schools, teachers complained about excessive noise from the unit ventilators. Poor workmanship in the original installation of one unit ventilator caused it to freeze up in cold weather. Water leakage was a problem in one of the schools visited. In general, the older type units seemed to give the most problems to the maintenance staff. Poor arrangement of ceiling-mounted lights creates difficulties in some schools. The lights are arranged in a manner such that they cause air from the unit ventilators to "dump down" on the students.

The quietness of operation of classroom unit ventilators with respect to original design was rated as excellent in 66 percent of the buildings, good in 29 percent, fair in 5 percent, and in no case was it rated as poor. The condition of the air filters was excellent in 62 percent of the buildings, good in 31 percent, fair in 5 percent, and poor in only 2 percent. The overall operating condition of the units was rated as excellent in 57 percent of the buildings, good in 36 percent, fair in 2 percent, and poor in 5 percent.

Item 10. Roof exhaust fans were observed in 89 of the 100 buildings visited. In one building, the motor on the roof exhaust fan had to be replaced three times in a period of ten years. Belt problems were frequently observed in these units. In one building visited, a problem of exhaust fan freeze-up was resolved by keeping fans in operation 24 hours a day. This is an expensive way to solve the problem because heated air is exhausted continuously. The roof exhaust fans in a couple of buildings were badly rusted, and in another building they were noisy enough to be disturbing in some of the classrooms.

The condition of the roof exhaust fans was rated as excellent in 29 percent of these buildings, good in 65 percent, fair in 6 percent, and in no case was any exhaust fan rated as poor.

Item 11. In one building, the central ventilation system was used only a couple hours per day and, therefore, the ventilation is inadequate in much of the building. In several buildings, the central ventilating equipment was entirely removed to use space for other purposes. In a large number of the buildings visited, no ventilation was evident in a large portion of the building. In some of the buildings, the access to the central fan room is very poor. For example, in one building, a vertical ladder through a hole in the floor was the only means of gaining access to the ventilation equipment room. This made it very difficult to perform maintenance, with the result that the staff did not check the equipment often enough. In general, there appeared to be a lack of understanding by the head custodian of why ventilation is necessary in school buildings.

The condition of the central ventilation system was rated excellent in 37 percent of the buildings which contained such a unit, good in 36 percent, fair in 14 percent, and poor in 13 percent.

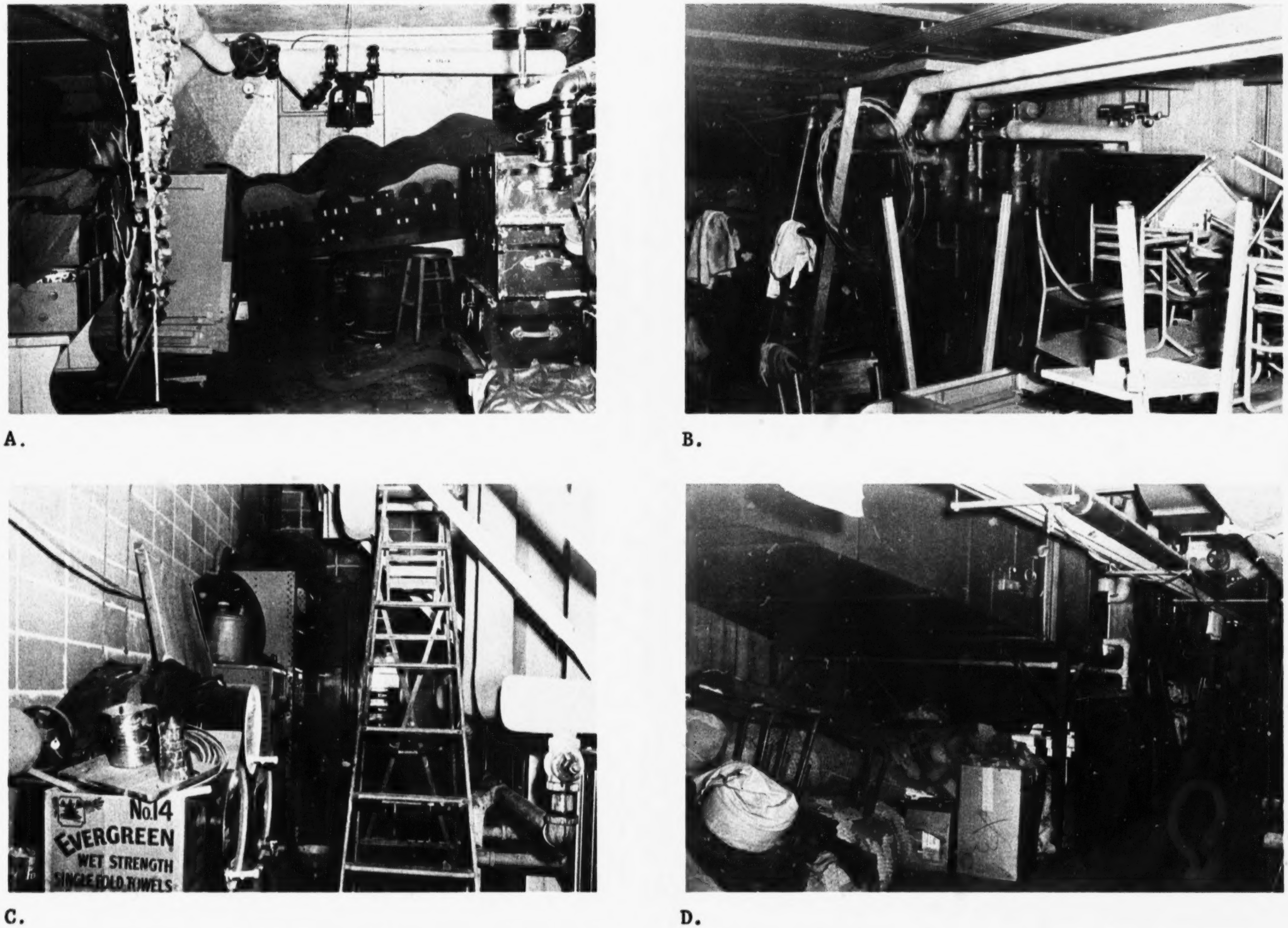

A.
B.
No.14
EVERGREEN
WET STRENGTH
SINGLE FOLD TOWELS
C.
D.

FIGURE 26. EXAMPLES OF POOR STORAGE FACILITIES

Item 12. Door closures, locks, door checks, and "panic hardware" were the most frequently mentioned items of hardware that gave trouble to maintenance men. The condition of hardware, door closures, locks, etc., was rated excellent in 30 percent of the buildings visited, good in 55 percent, fair in 10 percent, and poor in only 5 percent.

Item 13. Item 13 was included on the on-site visit check sheet so that the observer could make specific comments pertaining to the general conditions and maintenance procedures followed in the school buildings. Condensation of the many comments that were made indicates that the major problems in mechanical equipment maintenance can be related to the following:

- Poor design practices. In a new and generally good-looking building, the head maintenance man appeared to be capable and to understand mechanical maintenance procedures. He is hampered, however, by the built-in shortcoming of some equipment. For example, access to the main ventilation fan room (with 506 units) is up a ladder on the wall and through a small floor hatch. This arrangement is inadequate for equipment servicing.

In several schools, poor architectural and engineering planning was observed, presenting the schools with some serious maintenance problems. In one school, water piping is buried under slabs and in walls (they have hard water problems to begin with). There is no way to repair these pipes when they lime up or break. Classroom unit ventilators for the gym are mounted on brackets high up on the side wall, making them difficult to service. Domestic hot water leaves the boiler room at over 190°F. When asked about this, the head custodian said "they do this to get 180°F water for dishwashing". Water softeners were frequently observed to be improperly sized, most often being too small for the building.

In another building, many of the problems were designed into the structure. The building is set too low on a flat site, and in the spring, water runs into the building from outside. The unit ventilator intakes are almost at ground level, and problems with snow, water, weeds, etc., are evident. The burner controls were wired incorrectly when they were installed, requiring correction by the head maintenance man. The boiler feed-water arrangement was also incorrect, also requiring correction by the head maintenance man.

Several examples of poor installation practices are shown in Figure 27. In Figure 27A, a ceiling-mounted unit ventilator (protruding to the right out of the ducts) is almost enclosed by ductwork. This arrangement made the unit inaccessible for maintenance and servicing. One sees in Figure 27B that the incinerator blocks the cleanout door to the chimney, thus making chimney cleaning a difficult task. In Figure 27C, the small access door in the middle of the picture is the only way to enter a large fan room. Entrance is, therefore, difficult and, since a ladder must be placed in front of the doorway below in order to enter the fan room, hazardous. The access trap door in 27D is the only entrance to a main piping tunnel. It has been made useless by the installation of permanent bookcases.

- Lack of adequate space. The lack of proper storage space was evidenced in several of the buildings. In one of the buildings, all of the fan rooms are used for storage, and the main electric panel boards are practically buried behind civil defense and other stored materials.

- Insufficient time for proper maintenance. Several of the head maintenance men said that they did not have sufficient time to carry out a proper preventive maintenance program. Items are repaired as they break down. Much of their efforts are diverted to cleaning floors, repairing plaster in some areas, and other custodial duties. In many cases, the personnel are fairly well qualified, but appear to be so busy with normal custodial duties that emergency problems are hard to handle.

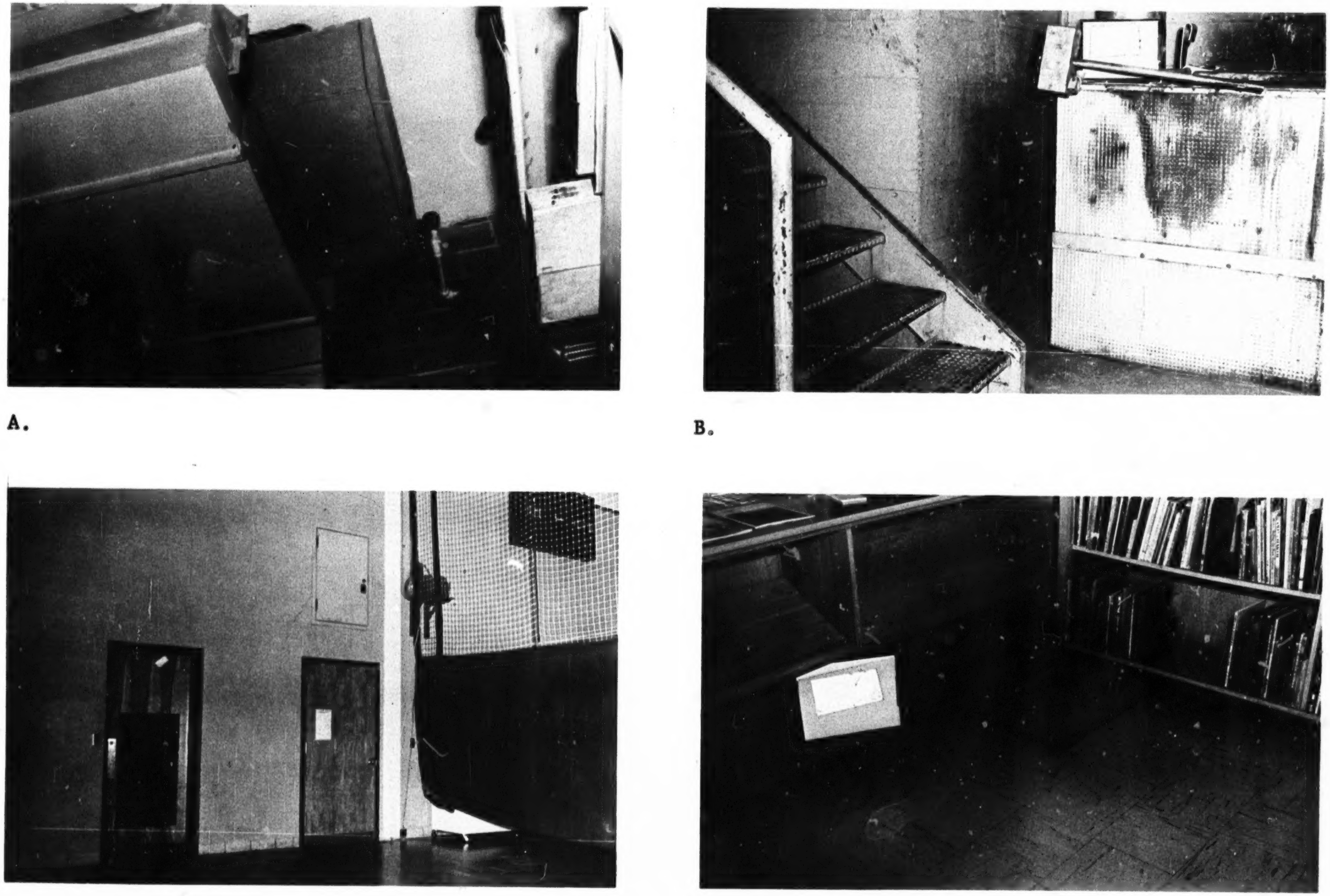
In one well-cared-for building, the chief engineer believed strongly that he should be able to spend more time with equipment and less with housekeeping. His time is presently scheduled by others, and it includes a lot of time for housekeeping. In another school, the chief engineer said that he has trouble getting help that is even qualified for housekeeping. In other schools, dirty boiler rooms were observed, partly caused by limited custodial time.

- Budgetary problems. These were evident in many of the schools visited. In one of the buildings (which had been added to several times), the mechanical system had never been brought up to an adequate level. There are many temperature control and ventilation problems, and equipment orientation is bad. The additions were built in the cheapest way, without regard to good heating and ventilation practice.

In another school experiencing budgetary problems, if something breaks down, repairs are improvised. The staff appears to be too small, requiring that maintenance be performed on a breakdown schedule.

In one of the schools, the chief maintenance man has too many duties to perform to properly maintain the OME and the building. When equipment breaks down, they call the local plumber to make the necessary repairs. Repair and replacement of faulty equipment is made only on a breakdown basis, and no preventive maintenance was evident.

In one of the schools that was visited, three people are taking care of a 900-pupil building. The pay level is low to a point where all of the help have a second source of income; for example, the head maintenance man also runs a farm.



A.

B.

C.

D.

FIGURE 27. EXAMPLES OF POOR INSTALLATION PRACTICES

Budgetary problems have prevented keeping some equipment in operating condition in another building. Belt guards had been removed from two ventilating units and had not been replaced. Filters should be added to the central fan system, vacuum pumps should be repaired or replaced, and draft control dampers on the boilers should be repaired and made operational.

A particularly poor practice was observed in two of the buildings visited. The district superintendent apparently is responsible for the decision to burn reclaimed oil (seven cents per gallon versus ten cents per gallon for good oil). This practice could eventually lead to high repair bills that will cost the school district much more than the small savings in oil costs.

- Improperly trained and inexperienced operators. The following general observation is typical of the problems encountered by a new maintenance man in a previously neglected school building. The present man in charge is new this year. He has an inadequate staff, most of whom are lacking in skills (he fired one recently for drunkenness). This man inherited a completely rundown system. He has not been able to get funds or personnel to do what has to be done for proper maintenance and to put the building back into top-notch shape. He is dedicated to trying to get the building into shape, but almost complete neglect over the previous ten years has left him with a tough problem.

In one of the school buildings, the chief maintenance man was found to be weak technically, not knowing the proper switches to push or the proper valves to turn. He apparently did not know what was happening and was just able to keep the building maintained so that it was usable.

One of the schools had a very capable chief maintenance man. Previous to his present position, he had worked for about 25 years in mines, and appeared to be capable in maintaining mechanical equipment because of his previous experience in piping, welding, angle-iron fabrication, etc. Six years ago, he had ten men to help him. Today, he has five and two of these are bus drivers. He is, therefore, short-handed.

In some of the buildings visited, the head custodian had attempted to improvise certain types of equipment without proper knowledge of construction procedures. For example, one engineer had built a home-made water heating system. The school had changed from Number Five oil to gas and Number Two oil. Since the oil heaters were no longer needed, the engineer salvaged an old steel tank, piped it up with black steel pipe and a pump, and is using the old oil heaters to heat domestic water. He had installed no temperature control and no safety valve on the system.

- Existence of much obsolete and wornout equipment. An example of some of the older buildings is one built about 1910. Everything appeared old and worn; since future use of the building is uncertain, no effort is being made to modernize or keep things up-to-date. Some of the older buildings are being maintained just well enough to keep them usable. In some cases, modernization would be costly and would still not provide an acceptable school building by present-day standards.

In many buildings, good examples of proper maintenance procedures were observed. In these buildings, the men are generally dedicated and intelligent, and show a strong interest in maintaining and upgrading their proficiencies. Some of the good examples are as follows:

- In one of the schools that is in excellent condition, the maintenance men have a motor lubrication schedule and keep records of maintenance. These men disassemble, clean, and repair major boiler operating controls on an annual basis. Of all the buildings visited, this one came closest to having a preventive maintenance program of the type desirable for all schools. The maintenance people take pride in their jobs and their ability to do things, and the results show it.
- In another school, the staff exhibited excellent control over all problems. All OME is checked at least twice daily. Lubrication is performed on specific schedules, and all equipment is thoroughly cleaned inside and out. The fan drive and belts are all adjusted for perfect alignment and belt tension. The boiler and swimming pool water are tested daily, and the school staff exerts excellent control of all maintenance procedures.
- In one of the buildings that was in particularly good condition, the head custodian is a dedicated, hard-working man with 32 years of experience. He said he wished he knew more about ventilation, refrigeration, and electrical equipment. Burner service is farmed out, and general housekeeping is handled locally. Boiler water samples are sent to a commercial chemical house about twice each month for analysis, and the boiler water chemical treatment is as recommended by the manufacturer.
- In another well-kept building, the chief engineer has taken many night courses dealing with boilers, boiler room operation, and refrigeration. He is, therefore, capable of handling almost any problem that could arise.

- One of the schools visited stood out above all of the others. The building is being maintained in an excellent manner, and the maintenance people are knowledgeable of all aspects of their jobs. If a training program is going to be set up on operating mechanical equipment maintenance, this school system should be studied as a model operation.

The preceding discussion, although somewhat abbreviated, is representative of many of the comments made by the on-site observer.

Item 14. The on-site observer was requested to rate the overall maintenance condition of each building in Item 14. His rating for each school building, from excellent to poor, was tabulated according to the size of the district represented by the building. Assuming that the overall rating results for a particular size of school district are representative of all districts in this size category in the state, the number of districts of a particular size that fall into each classification (excellent, good, fair, poor) was determined. The results of this analysis, for all districts in the state, are presented in Table 9. This table shows that 62 percent of the one-school districts rate as fair or poor in overall maintenance. Ratings of fair to poor are also given to 32 percent of the two-school districts, 43 percent of the three-school districts, 73 percent of the four-school districts, 50 percent of the five-school districts, 40 percent of the seven-school districts, and 33 percent of the ten-school districts. In total, 226 (47.5 percent) of the school districts in Minnesota are estimated to rate fair or poor in overall maintenance condition.

TABLE 9

RATING OF OVERALL MAINTENANCE CONDITION FOR SCHOOL BUILDINGS IN VARIOUS SIZES OF DISTRICTS (BASED ON THE RESULTS OF THE ON-SITE VISITS).

| Size of district (Number of school Buildings) | Number of districts of this size in the state | Number of districts of this size that were visited during the on-site phase | Number of districts in the state rated as: | | | |
|---|---|---|---|---|---|---|
| | | | Excellent | Good | Fair | Poor |
| 1 | 239 | 24 | 30 | 60 | 75 | 74 |
| 2 | 113 | 22 | 15 | 62 | 28 | 8 |
| 3 | 39 | 7 | 11 | 11 | 8 | 9 |
| 4 | 15 | 7 | 2 | 2 | 5 | 6 |
| 5 | 14 | 6 | 0 | 7 | 4 | 3 |
| 6 | 10 | 3 | 0 | 10 | 0 | 0 |
| 7 | 10 | 6 | 2 | 4 | 4 | 0 |
| 8 | 5 | 2 | 0 | 5 | 0 | 0 |
| 9 | 3 | 3 | 1 | 2 | 0 | 0 |
| 10 | 6 | 4 | 3 | 1 | 1 | 1 |
| 11 or more | 22 | 16 | 13 | 9 | 0 | 0 |
| Total | 476 | 100 | 77 | 173 | 125 | 101 |

It is interesting to note from Table 9 that the major maintenance problems appear to occur in the smaller districts, that is, for five-school districts or smaller. The larger districts (more than ten schools) do not appear to have nearly as many problems with maintenance as the smaller districts. This is probably attributable to the fact that larger districts usually have a central maintenance staff of capable men, equipped to handle maintenance duties more efficiently.

Other general problems were observed during the on-site visits, as shown in Figure 28. Moisture was condensing in the kitchen exhaust hood, shown in Figure 28A, and then dripping back into food during preparation. Many examples of door hardware problems were observed. Many doors had to be chained at night to prevent vandalism (Figure 28B). Several unit ventilator fresh-air intakes, shown in Figure 28C, were blocked with cardboard or plywood. With such blockage, fresh air entered the room only by seepage through cracks and rooms became stuffy. In one school building that had its own well, the water pressure fluctuated to the extent that the wash fountains could not be properly adjusted. Therefore, the piping was dismantled and the fountains used as flower pots (Figure 28D). Two of these four- to five-hundred-dollar pieces of equipment were so utilized.

A lack of adequate space in one school building made it necessary to use a portion of the boiler room for a laundry room and food preparation and storage area (Figure 29A). The valve control assembly of a central sprinkler system is shown in Figure 29B. This assembly, located in a classroom, could be easily tampered with by students. In Figure 29C, a gas valve venting pipe was installed through a combustion air intake damper. Any vented gas could be easily drawn back in through the dampers, creating a fire or

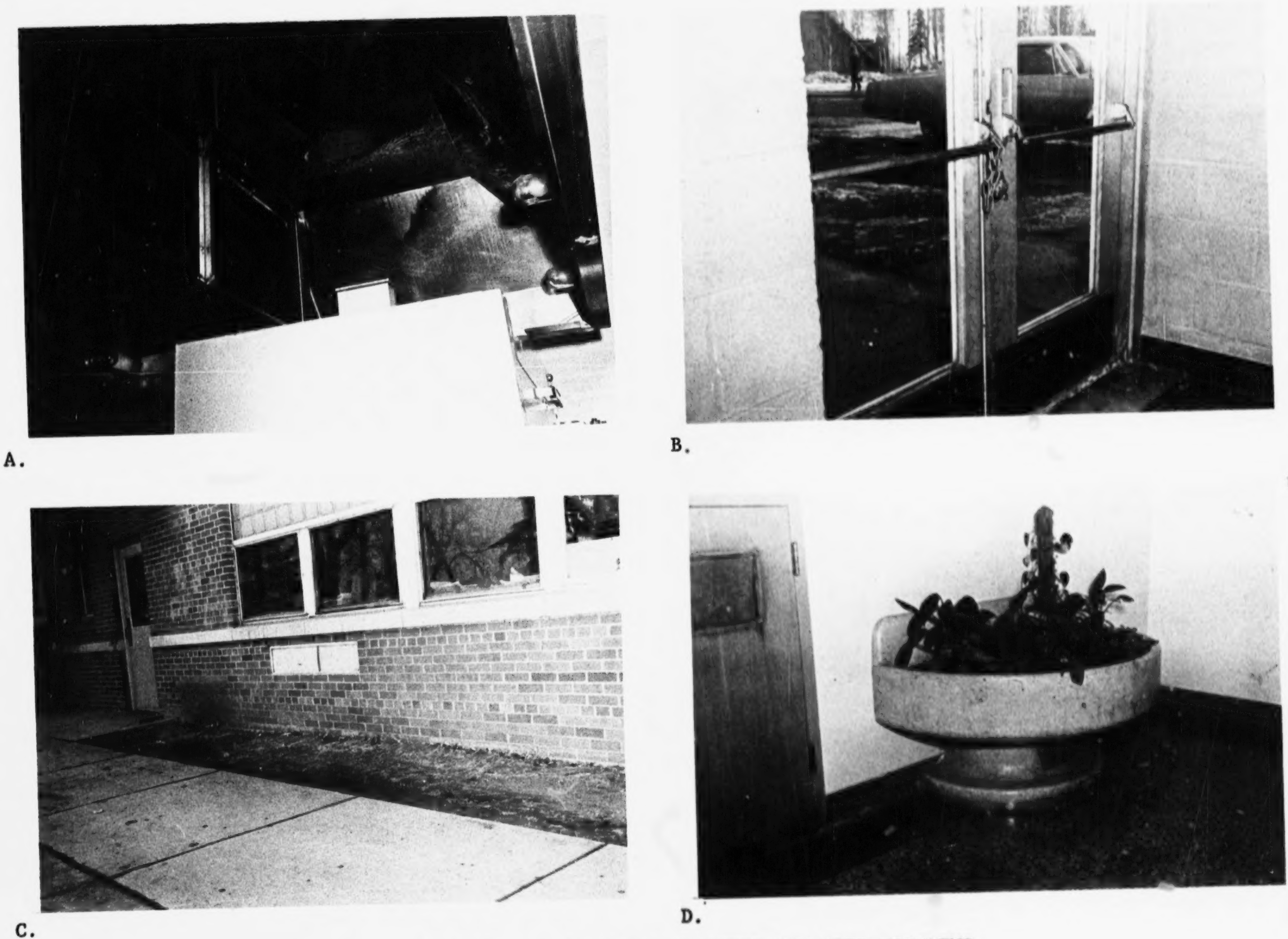
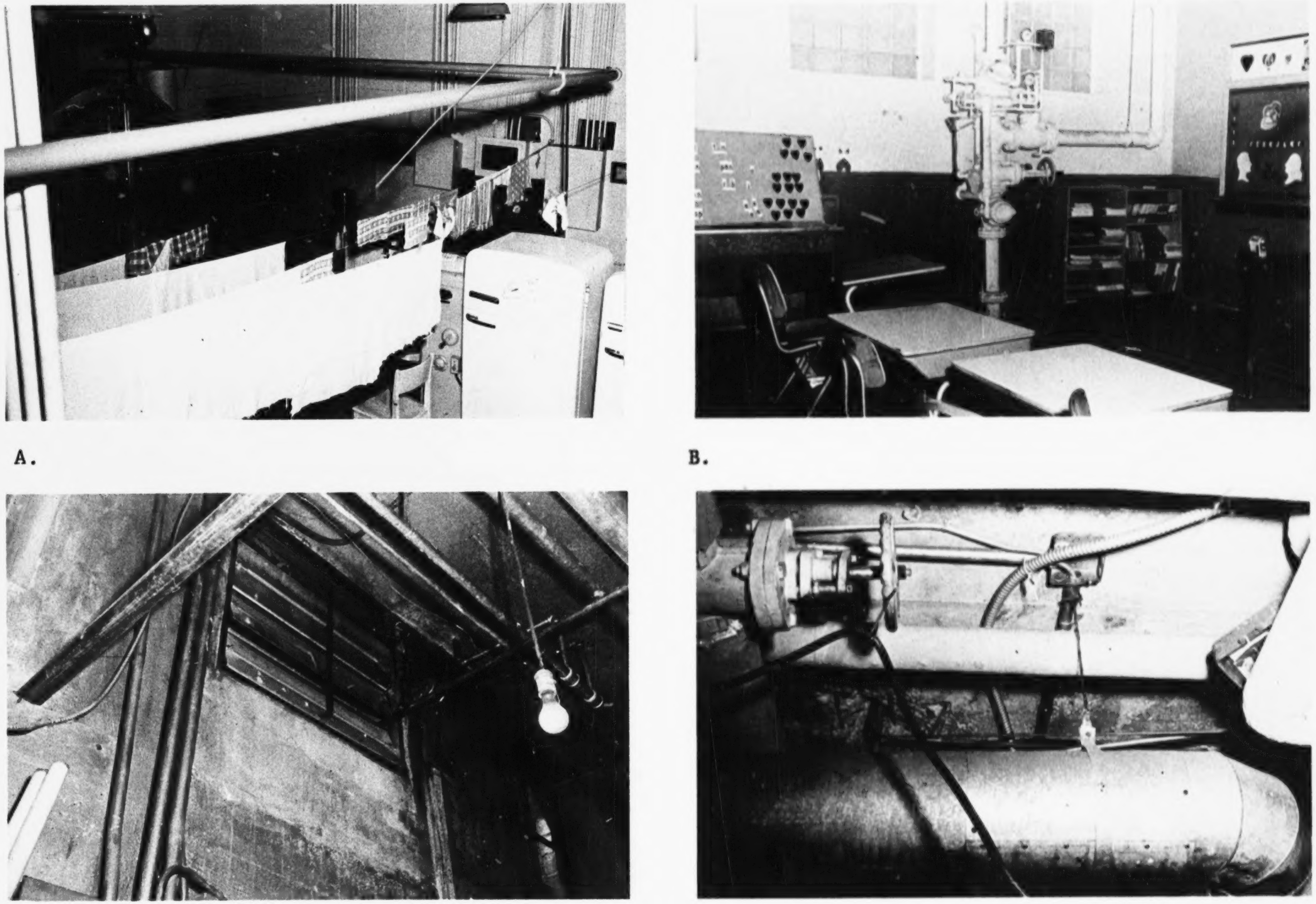


FIGURE 28. EXAMPLES OF OTHER OBSERVED PROBLEMS



A.

B.

C.

D.

FIGURE 29. EXAMPLES OF OTHER OBSERVED PROBLEMS

explosion hazard. Another potentially hazardous situation is shown in Figure 29D. The breaching from an oil-fired water heater is shown at the bottom of the picture. The strap used to support the breaching is attached to an electrical conduit on the ceiling. This arrangement could be a fire hazard.

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